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Ecological design patterns for green neighborhoods

Joseph P. Goldman
University of Tennessee

To the Graduate Council:

I am submitting herewith a thesis written by Joseph P. Goldman entitled "Ecological design patterns for green neighborhoods." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Architecture, with a major in Architecture.

R. Mark DeKay, Major Professor

We have read this thesis and recommend its acceptance:

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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Edward J. Jepson

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Ecological Design Patterns for

Green Neighborhoods

A Thesis
Presented for the
Master of Architecture
Degree
The University of Tennessee, Knoxville

Joseph Paul Goldman
May 2009

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Abstract

Contemporary neighborhood design best practices respond to social and economic system factors. However, ecological problems, including water pollution, air pollution, and habitat destruction, have prompted the need for improved environmentally responsive patterns for neighborhood planning and building. Sustainable design focuses on creating human environments based on how ecological systems function. Through the analysis of ecological systems and contemporary neighborhood design best practices, design patterns can be formulated for the design of green neighborhoods. The purpose of this thesis project is to formulate ecological design patterns for designing green neighborhoods.

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Chapter 1

Sustainable Design

"Sustainability"

The term sustainability, as derived from the fields of biology, pertains to a living system's "constant struggle to develop, to change, and to respond to disturbance" and "refers to the ability of systems to maintain or maximize themselves over time" (Jepson, 500). In order to have a sustainable system, there must be a balance between energy consumption and energy production over long time periods. This process revolves around the ability to export "bound" (unavailable) energy and import "free" (available) energy, equilibrating a systems' level of energy consumption. A system that has this ability to transfer bound energy with free energy is known as an open system (fig. 1). A living system is an open system comprised of numerous interdependent systems that function to maintain the overall organism. An ecosystem is an example of a living system. For example, the earth as a single ecosystem consists of and infinite number interdependent systems, including photosynthesis and the hydrological cycle. Each interdependent system within a living system is consuming energy that must be compensated for in order to keep the overall system working. Entropy is the term that describes the state of deterioration that a system is undergoing as it constantly transforms energy. As stated in the second law of thermodynamics, "a reduction in entropy in one part of a system can only be achieved if there is a corresponding and equal increase in entropy elsewhere in the system" (Jepson, 500). Open systems can overcome this state of disorder, because they have the ability to transfer bound and free energy and can theoretically sustain

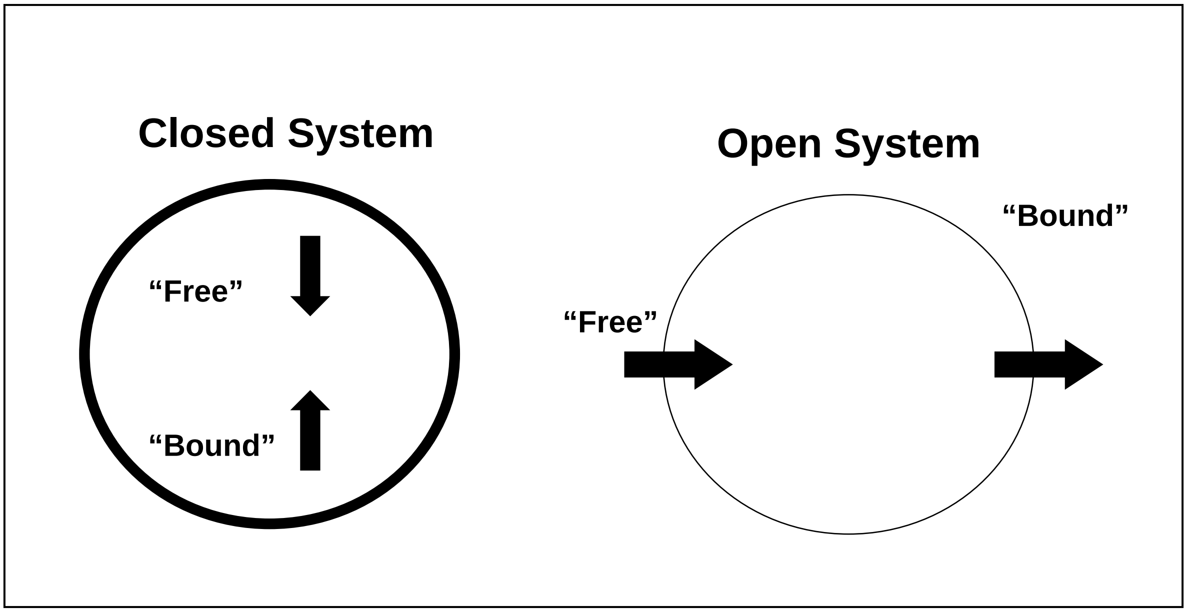

Figure 1: System Energy Cycle
This diagram represents the energy cycle of a closed and open system. "Free" represents the energy available for use. "Bound" represents the energy not available for use.

themselves as long as there is energy to absorb. Still, in order to maintain a stable system, a balance must be created between the interdependent systems. Monitoring a system's carrying capacity can help in determining if a system is becoming unbalanced. Carrying capacity refers to the ability of a system to support its interdependent system components. If the system begins to exceed its carrying capacity, the energy use of the overall system may reach a critical state and eventually breakdown (fig. 2). Ecologists classify the breakdown of a system in four stages: "drawdown", "overshoot", "crash" and finally "die-off" (Sale, 24-26). Kirkpatrick Sale, in his book *Dwellers in the Land*, explores these scientific phenomenons and relates them to humanity and the impact humans have had on Earth's ecosystem. "Drawdown," refers to a "dominant species…use of surrounding resources faster than they can be replaced and so ends up borrowing…from

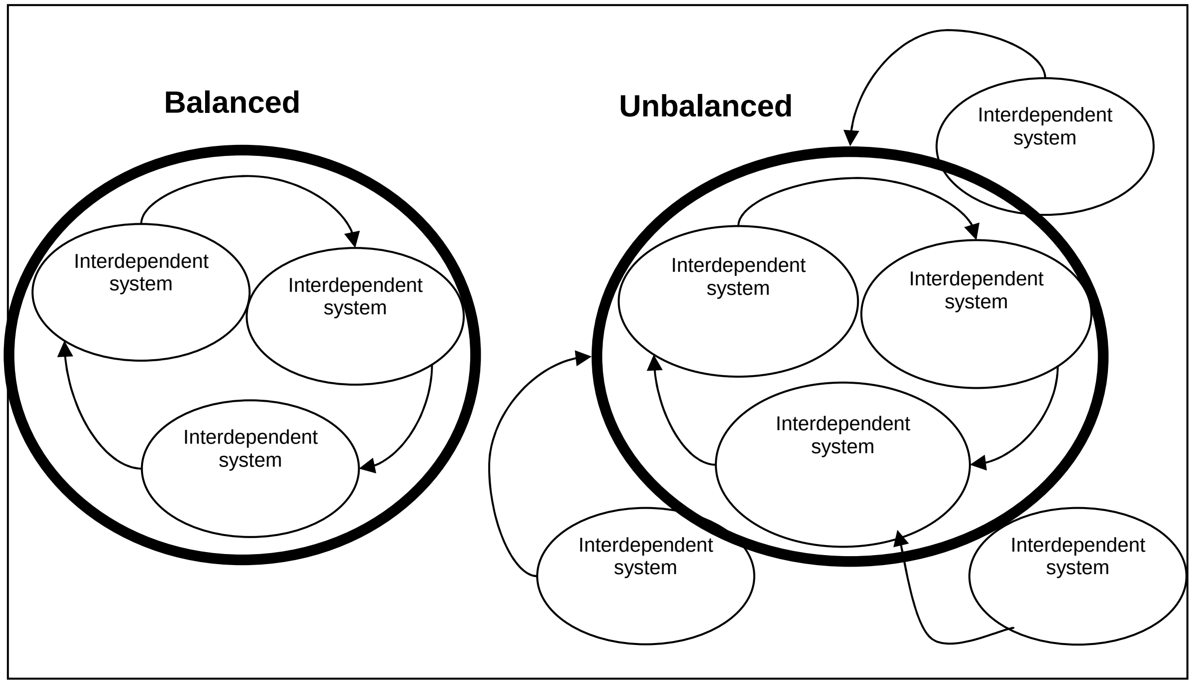

Figure 2: System Carrying Capacity
This diagram represents the carrying capacity of a system. A balanced system, as shown the left, can sustain the interdependent systems within. An unbalanced system occurs when the amount of energy needed to sustain the interdependent systems can not be met by the overall system. At this point the overall system has exceeded its carrying capacity and risks die-off from energy depletion.

other places and other times." Sale uses human reliance on fossil fuels as an example of "drawdown." The second stage, "Overshoot," is the "inevitable and irreversible consequence of continued drawdown, when the use of resources in an ecosystem exceeds its carrying capacity and there is no way to recover or replace what was lost" (24). Sale's research places human existence at either the first or second stage of "die-off", however he notes that other researchers believe we have already reached "overshoot" (36). How then do we interpret signs of instability, and what can we do to try and alleviate society's harmful affects on the earths' ecosystem?

Sustainable Development

Urban systems such as cities, communities, and neighborhoods, function similarly to ecological systems (fig. 3). They are organized as a means of production and consumption for the development of humankind, sustained through the importing and exporting of materials and waste, have limited carrying capacities in terms of land space and resource availability, and depend on interdependent systems to sustain the overall system. However, if the functional relationships between an urban environment and an ecological system can be compared, so can the four stages of a system breakdown. Attempts at understanding the relationships between humans and nature, and their affects on the ecosystem, have become principle factors in determining how to successfully avoid the deterioration of the urban environment. Two major factors that affect this breakdown are urban sprawl and the lack of environmental considerations in urban codes. Over the past fifty years, architects and urban designers have become key players in the struggle to develop a more effective method of building into the natural environment. Sustainable design and green development exemplify the response to problems between natural and urban environment. Recognizing sustainability as a balance that must occur within an overall system, the conclusion can be drawn that all of the interdependent components that make up the urban system must be working effectively. If this is to happen at the scale of cities and neighborhoods, there needs to be a collaborative study between designers and planner to determine methods of maintaining a balance within the social, economic and environmental systems so as to create a sustainable urban environment. The World Summit on Social Development defines sustainable development as *"the framework for our efforts to achieve a higher quality of life for all*

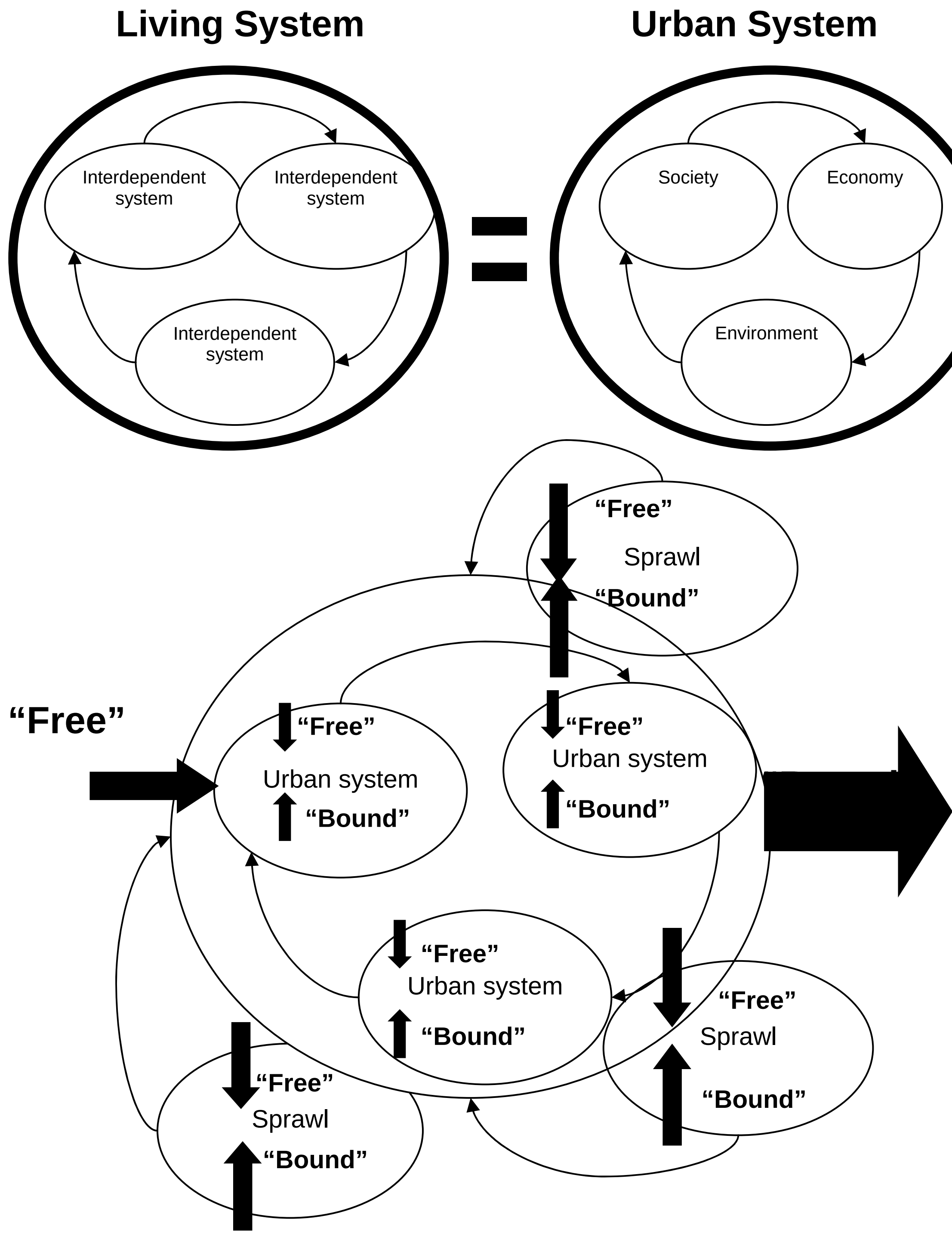

Figure 3: Ecological to Urban System Comparison
This image is an abstract representation of the effect sprawling communities have on urban systems as applied through the living system diagram. As shown in the diagram, the urban system, i.e. city, neighborhood, etc., requires a specific amount of energy and resources to sustain its ecosystem. When the urban systems begin to divide and migrate outside of their ecosystem boundary, sprawl, there grows a risk of exceeding the systems carrying capacity. If left alone, the system will become unbalanced and crash.

people," in which *"economic development, social development and environmental protection are interdependent and mutually reinforcing components"* (United Nation). In order to do this, a method of design must be established that works to strengthen and balance social, economic and environmental systems within the urban environment. A design tool that is currently being integrated into the creation of cities and neighborhoods is the design pattern.

Chapter 2

Design Patterns

Process Patterns

Fritjof Capra defines patterns as commonly occurring interdependent elements that collectively form a network. All life, he explains, is part of one living network, the ecosystem (Capra, 5-6). Within the pattern of life network are a number of smaller interrelated networks, which can be mapped in terms of their related patterns. Capra's method of mapping living networks focuses primarily on process patterns. The process patterns are defined by activities, such as processing and transformation, as well as the movement of energy, information, and materials that are part of all ecological systems (DeKay, 4). Capra further characterizes the living network as always fluctuating. This is because the process patterns within the network fluctuate depending on certain influences. For instance, he says population density is a fluctuating process of the ecosystem network. This is because the population of different species is always changing in relation to influences such as resource availability and predator-prey cycles. Similarly, temperature is a fluctuating process within the human body network (Capra, 8). This being said, it is imperative that a dynamic balance be maintained between these network process fluctuations. If one process pattern is destroyed, its affiliated network will be damaged, or may even breakdown. By analyzing the function and organization of process patterns, a design methodology can begin to be established. John Lyle, in his book *Regenerative Design for Sustainable Development,* has created a series of diagrams based on ecological system processes (fig. 4). These diagrams are based on the natural

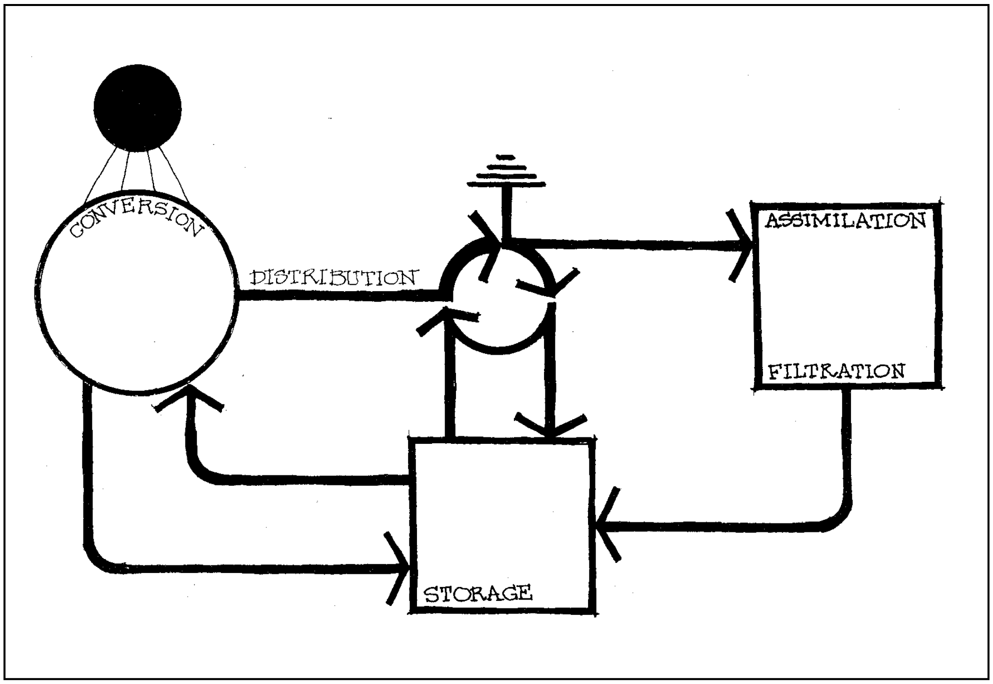

Figure 4: Regenerative Ecological Process
This image is of a process diagram taken from John Lyle's *Regenerative Design for sustainable Development* (Lyle, 26 & 142). The diagram maps the regenerative processes of Ecological Systems.

regenerative cycle of ecological processes without the affect of human interaction. By analyzing the ecological system processes, design patterns can be developed that work with the natural system cycles and fluctuations, not against them.

Spatial Patterns

Another patterns analyst is Christopher Alexander. His book, *A Pattern Language*, proposed a design language through a process of identifying common problems at different scales and offering generalized design solutions. These solutions are defined as the patterns which collectively form a shared design language for buildings and towns with many possibilities for expression. However, unlike Capra, Alexander explores spatial patterns. Spatial patterns refer to the physical configuration of the natural and built environment in response to ecological, social, and economic events and patterns. For example, Alexander's pattern of "Parallel Roads" addresses spatial patterns that work with physical formations, such as traffic flow (fig. 5). In another pattern titled "Courtyards Which Live" the spatial organization is defined in response to patterns of events that one wants to have happen there (fig. 5). Each spatial pattern is a reflection of a specific contextual system of forces. For instance, the "Courtyards Which Live" pattern is meant as a solution to resolve social process patterns by creating a more interactive human environment. Spatial patterns are also apparent in the collection of American urbanism called *The New Civic Art* (fig. 6 & 7). The American urbanism patterns, however, have been primarily formulated in response to processes within the social and economic system. Before exploring ecological system design patterns, this study will further explore how to create design patterns.

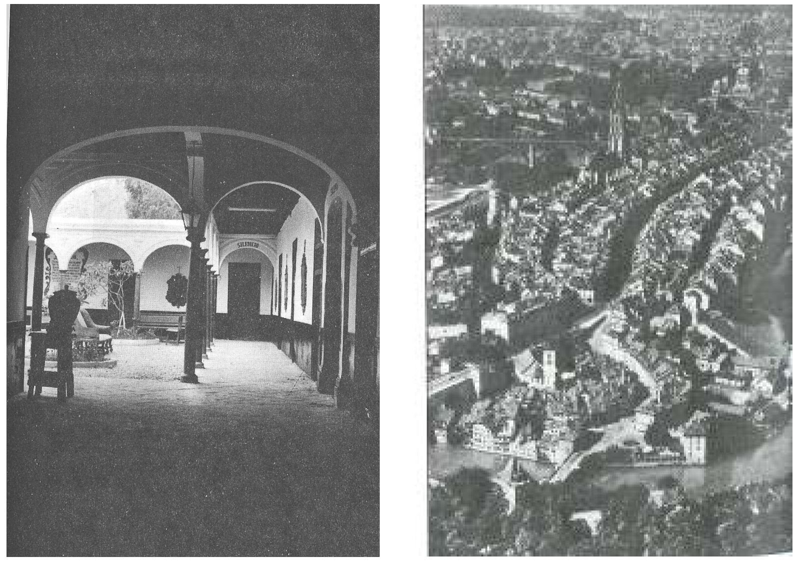

Figure 5: Spatial Patterns
These images are from Christopher Alexander's *A Pattern Language* (Alexander, 56 &126). The image on the left represents the "Courtyards which live" pattern, which can be analyzed in terms of its structural design and physical layout spatial pattern. The image on the right represents the "Parallel roads" pattern, which can be analyzed in terms of its manipulated landscape and vehicular spatial patterns.

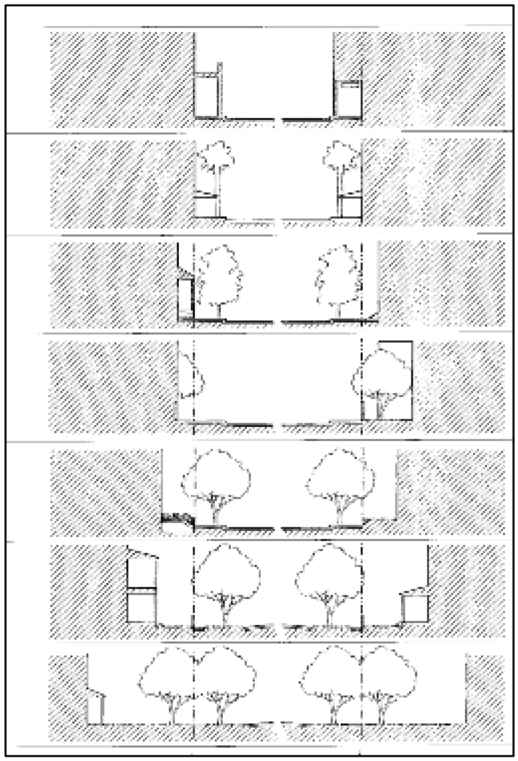

Figure 6: Streetscape Patterns
This image is from *The New Civic Art* (Duany, 189). These are several streetscape patterns for building frontage and pedestrian walk. The street frontages shown in this image demonstrate the use of trees and building encroachments to create a neighborhood character.

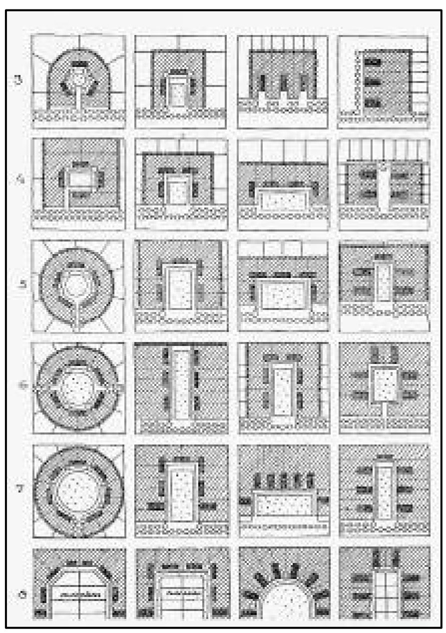

Figure 7: "Closes" Pattern
This image, from *The New Civic Art*, shows pedestrian "closes" patterns for determining building setbacks from spaces such as cul-de-sacs (Duany, 170). This image demonstrates multiple solutions to building layouts at the end of streets.

Formulating Design Patterns

Having defined process pattern and spatial patterns, a methodology can be created to be used as a tool for formulating design patterns. Design patterns are the configuration of the relationships between the process patterns and the spatial patterns. Through the synthesis of a systems process and spatial patterns, a design pattern can be created (fig. 8). For example, if creating an ecological design pattern, the first step is to identify the system. If the system is water, then an analysis would be done of water process patterns, such as the hydrological cycle, and spatial patterns, such as drainage channels, streams, and creeks. By combining the analysis of ecological system spatial and process patterns, an ecological design pattern can be formulated that either protects or enhances the water system. By integrating ecological design patterns into contemporary neighborhood design, a green neighborhood can be improved or created.

Ecological design patterns are not without precedent. Randall Arendts' land conservation patterns are examples of neighborhood ecological design patterns (fig. 9). Arendt has formulated a series of ecological design patterns that have been derived from habitat and vegetation process patterns and spatial patterns. His design patterns can be used by architects and urban designers to help create an urban environment that works with the natural environment. In the book *Sun, Wind, and Light, 2nd Edition,* by G.Z. Brown and Mark DeKay, one can find an extensive list of climatic design patterns developed at multiple scales. DeKay's research is based on the analysis of climate contextual systems and how energy processes can be used in architectural and urban design. For example, the pattern entitled Breezy Streets was derived from the analysis of wind flow through the

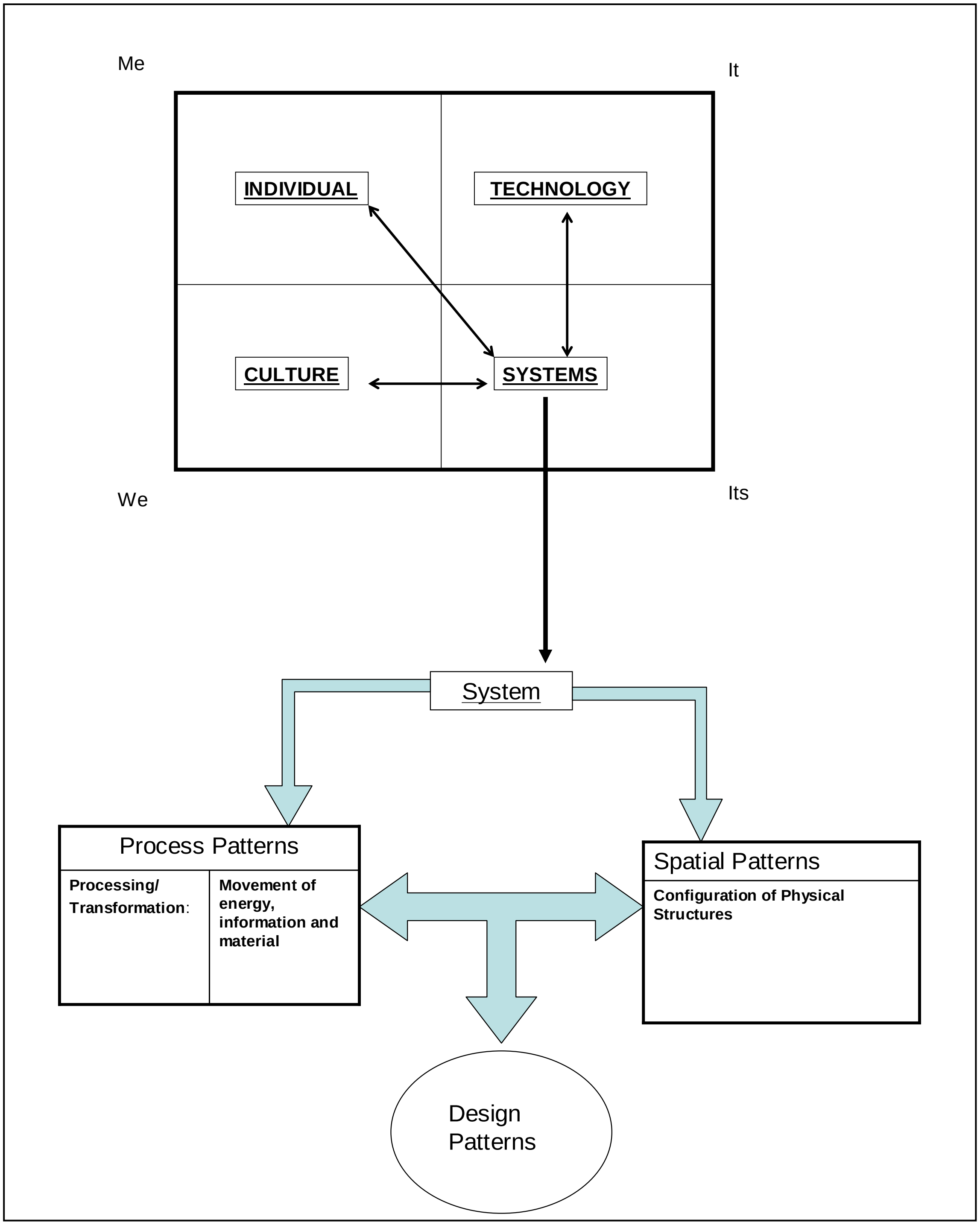

Figure 8: Formulating Design Patterns
This diagram maps the methodology of formulating neighborhood design patterns. It begins by looking at human interaction with ecological systems. The system is then analyzed as both process and spatial patterns. The process patterns are defined by activities, such as processing and transformation, as well as the movement of energy, information and materials, that relate to the event. The spatial patterns are the structural relationships defined and manipulated through physical form in response to the events. The configuration of the relationships between the process patterns and the spatial patterns produce design patterns. (DeKay, 4)

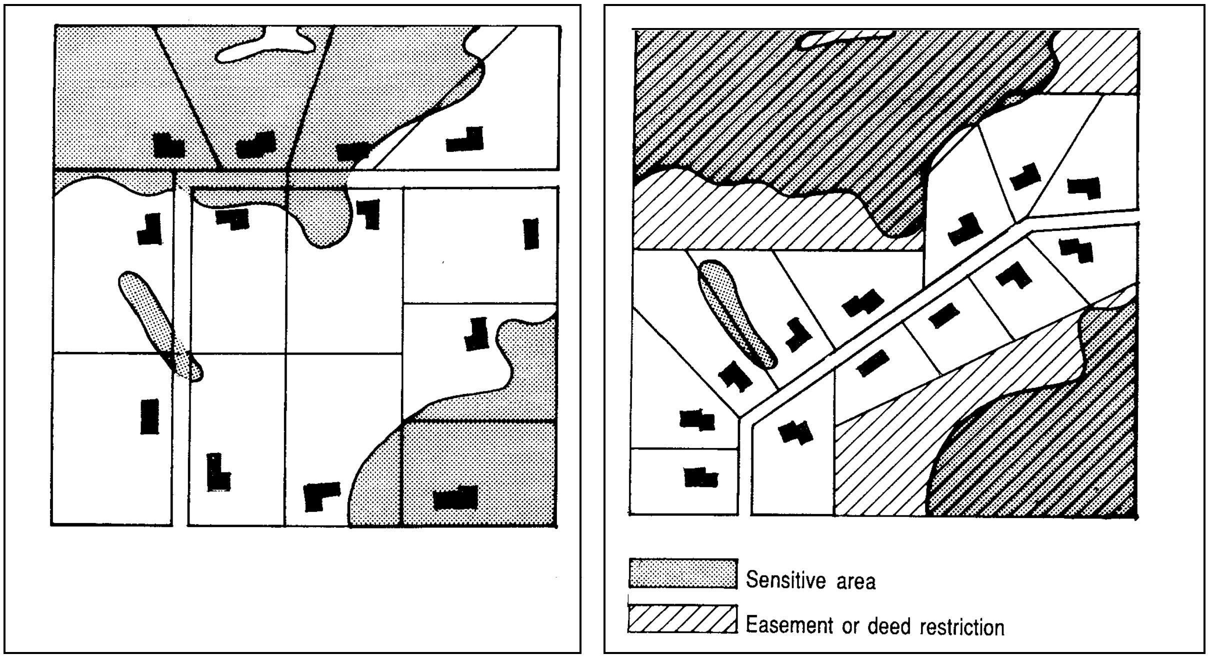

Figure 9: Randall Arendt Land Conservation Pattern
This diagram shows two neighborhood schemes (Arendt, 21). The picture on the left shows the conventional method of neighborhood design, which does not respond to the natural environment. The picture on the right shows how the same level of density can be achieved, while providing a more ecologically sensitive response to the natural habitat and vegetation.

built environment (fig. 10). This pattern can be used to control wind flow along streets in order to provide access to wind for use as cross-ventilation in buildings, along with sufficient cooling of streets in the summer. Though many patterns currently exist, they have not yet been integrated into contemporary neighborhood design best practices.

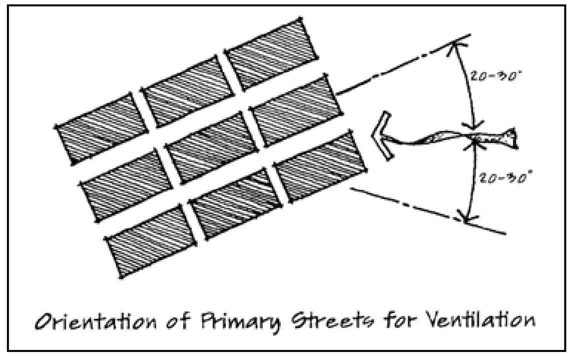

Figure 10: Breezy Streets Diagram
This diagram shows how building orientation can be used to direct wind flow and passively cool buildings at an urban scale (Brown and DeKay, 114-115).

Chapter 3

The Ecological Systems

Identifying the Ecological Systems

The ecosystem is a network of interdependent components that can be observed through process and spatial patterns. The ecological components that I will be analyzing to formulate design patterns are water, slope, wind, sun and shade, vegetation and habitat.

Water

Water flow, storage, and use are important factors in urban development. Design patterns formulated to address these factors is a necessity in creating a green neighborhood. Roads, sidewalks, and other paved landscapes can produce water runoff that, if not channeled properly, will affect the rate of water absorption and harm surrounding water sources (Lyle, 162). By looking at the processes and spatial patterns involved with natural water flow and the hydrological cycle, design patterns can be established to help alleviate the associated problems (fig. 11). For example, by charting water flow patterns along a given site, a design pattern for locating green spaces and street drainage can be established (fig. 12). This can be achieved by designing streets, buildings, parks, and greenways in a manner that promotes the natural water flow patterns. Similarly, when building into an already developed site, the removal of streets and other urban elements should be considered if beneficial for natural water flow patterns. An example of this is a street that has been built over a blue stream or minor water channel. The water flow

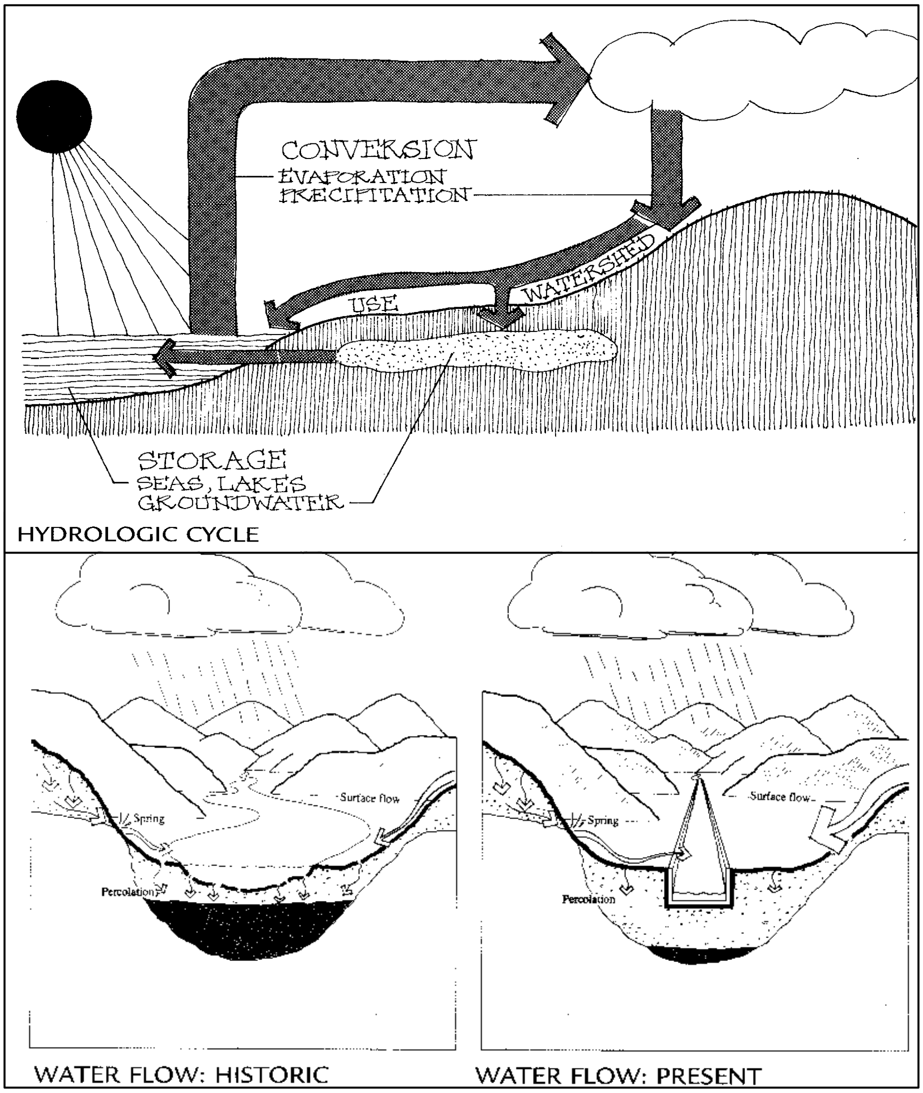

Figure 11: Water System Diagram
These images are from John Lyle's book *Regenerative Design for Sustainable Development* (Lyle, 162). The Top Image is a diagram of the natural process and spatial patterns due to the hydrological cycle. The bottom image demonstrates the process and spatial change due to human influence.

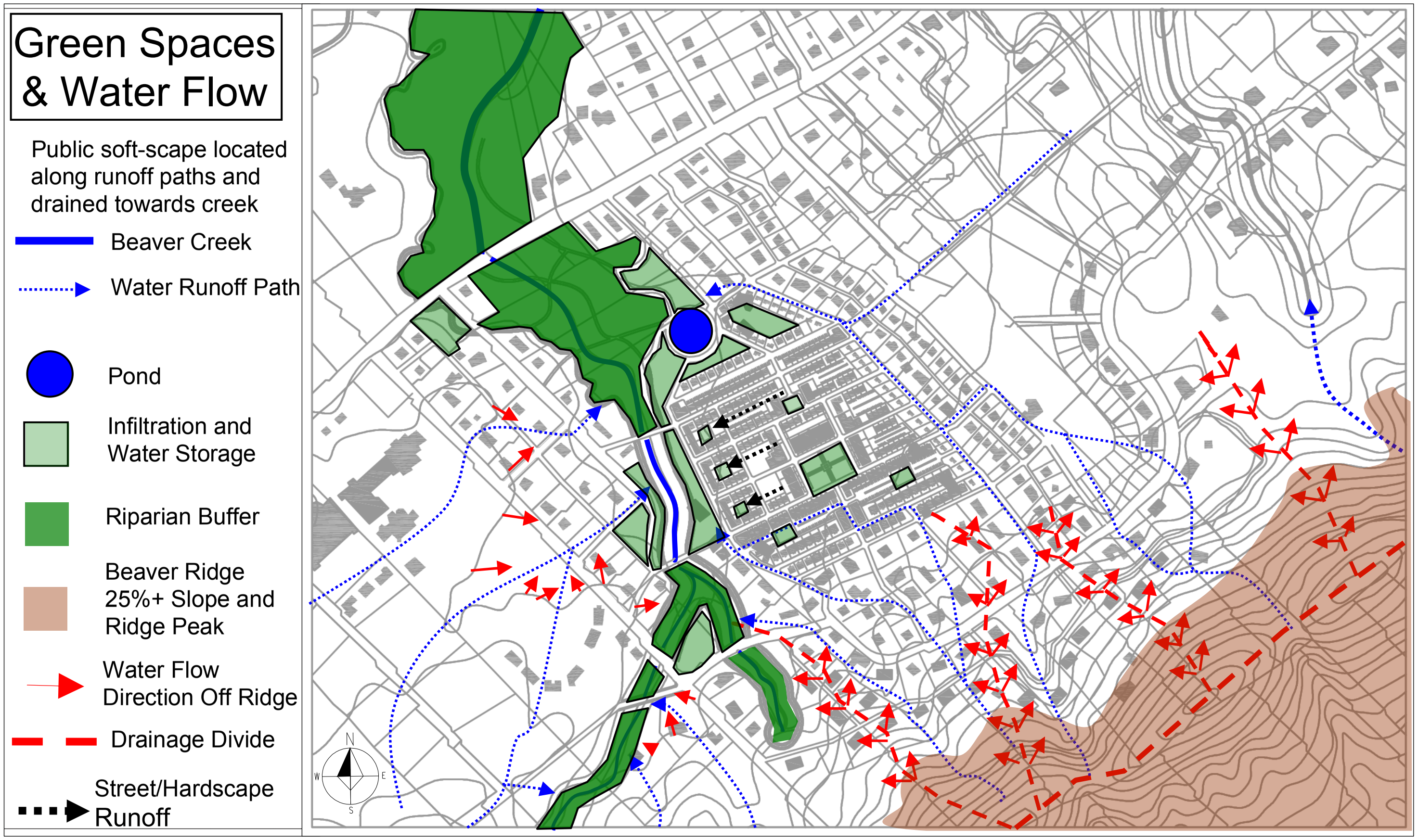

Figure 12: Water Flow Pattern
The green spaces and water flow pattern was used to determine the most logical points of infiltration and water drainage. By doing this, a water flow network was created that more efficiently returns water runoff to the Powell Neighborhood watershed. Refer to green spaces and water flow pattern Figure 30.

pattern from the stream must now be redirected around the street, causing a delayed return to a water source. By removing or redesigning the street, the streams natural water flow pattern can be reestablished. This scenario is an example of using ecological patterns to design an urban environment that preserves the natural environment.

Wind

Wind flow is necessary for providing sufficient air circulation through a building or site and helping to maintain a cooler environment in the summer. Air flow analysis has lead to urban design patterns that are used to plan building placement on a site in an effort to effectively allow air to circulate between the buildings (fig. 13). Cities and Neighborhoods can be configured to respond to air flow design patterns in ways that help circulate fresh air through the urban site, creating a healthier environment. Similarly, a neighborhood can be designed around wind flow patterns, planning the placement of buildings and vegetation to either block harsh winter winds or allow wind flow in the warm summer time. Wind flow design strategies can also be formulated to meet the needs of different climate zone. Wind flow patterns in the Colorado Mountains are not going to be the same as those in the beaches of South Florida. For this reason, wind flow design patterns must be adaptable to different climates and environments.

Slope

Understanding slope conditions is necessary to the preservation of natural land features, such as mountains and ridges, and in preserving local water and wind flow cycles. When

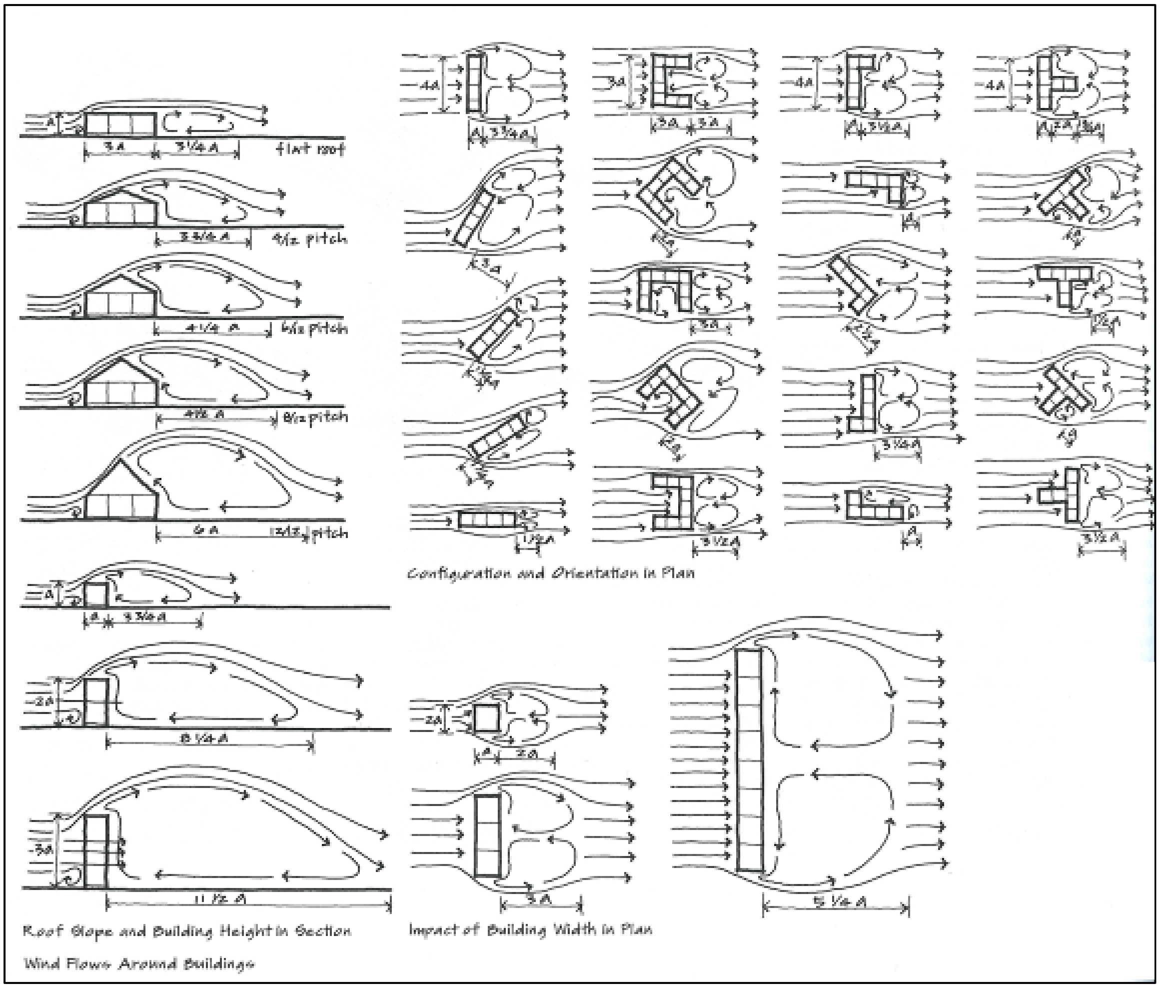

Figure 13: Wind Flow Pattern
These images are from *Sun, Wind and Light* (Brown and DeKay, 20). This is a building and air flow analysis demonstrating how environmental element can be patterned. From analysis, building orientation can be determined based on air flow patterns. Although this is a building scale pattern, it can be useful in planning and design of neighborhoods.

designing a neighborhood, slope grade analysis can help in determining housing locations. For example, areas with a 0-15 percent grade change might be suitable for larger, high density lots and buildings, while a 15-25 percent slope may be restricted to smaller, low density lots and buildings. This type of design pattern could help in protecting natural land features along steeper ridge and mountain locations. Similarly, preserving steeper slopes can help maintain the local water flow patterns. Steep slopes carry a number of water flow channels that are active during heavy rains. If a slope is manipulated without thorough analysis, it may alter a natural water flow cycle that sustains a given microclimate. For example, developing a ridge or mountain base could alter a natural mountain stream or natural runoff path. A disruption in any natural water flow cycle, if not compensated for, will induce change in overall microclimate. Because a microclimate is a living system, it is composed of and sustained by interdependent systems, i.e. water flow, wind flow, biotic and abiotic systems and cycles, etc. If one interdependent system is altered or disturbed, the entire microclimate will be affected. This is why ecological system design patterns are essential in urban development. Thus a design pattern formulated for building on ridges and mountains is imperative to the design of green neighborhoods.

Sun and Shade

When designing a city or neighborhood, the orientation of buildings and vegetation become primary factors for providing sufficient daylighting and shading. Passive system design at both the individual building scale and the neighborhood scale can play an important role in energy saving. Solar angle calculations have been developed for precisely this reason. By using solar angle calculations, solar design patterns can be formulated to locate and orient buildings to receive or block sunlight (fig. 14). A solar design pattern can help save energy cost by providing buildings with desired cooler season sunlight. This type of design pattern can be used effectively at the neighborhood and building scale. For example, a solar design pattern for colder climates may prescribe buildings to be oriented with the longest side of the building facing south. This is in an effort to have a building receive direct sunlight over its largest surface area. At the building scale, solar design patterns may require a higher percentage of glazing on southern walls allowing more direct sunlight into the building space. This design pattern combined with a neighborhood scale solar design pattern can improve energy savings during the cooler seasons by providing a building with an increase in daylighting and heat gain. Solar design patterns are an important addition to the design of a green neighborhood.

Vegetation

Forests and grasslands offer a great opportunity for vegetation design patterns. Trees provide a site with shading in the warmer seasons and act as wind breakers during cooler. Through the combined analysis of wind flow and solar angles, design patterns can be formulated to determine the location and species of neighborhood trees. Based on sun and wind orientation, for example, a large deciduous tree with a low shading coefficient can be used to provide ample shading in the summer time and less shading in the winter.

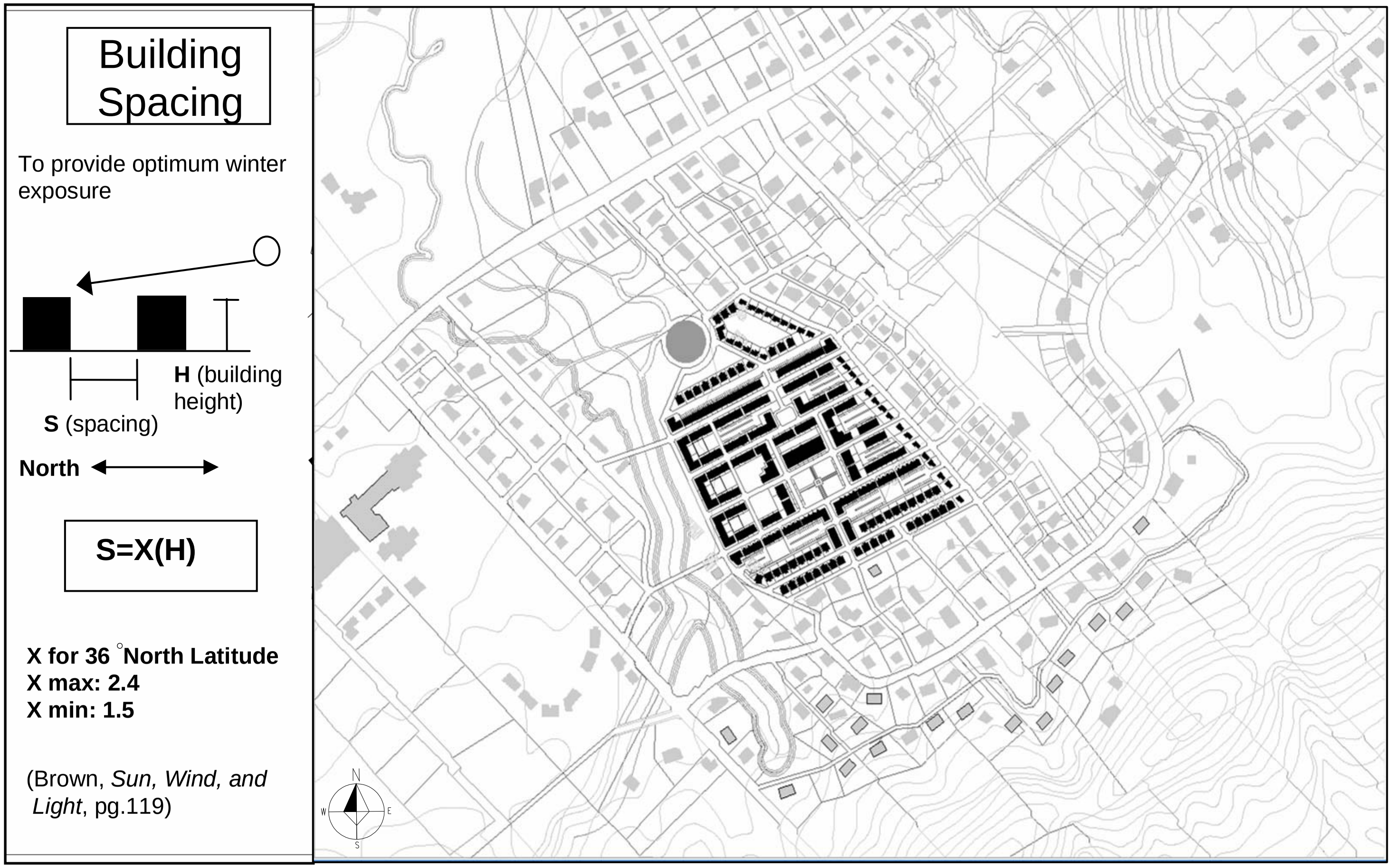

Figure 14: Sun and Building Pattern
This image is of a sun and shading pattern taken from Sun, Wind, and Light (Brown and DeKay, pg.119). This pattern was formulated based on solar angles at different times of the year and has been integrated into neighborhood design to provide sufficient daylighting and shading to groups of buildings. This pattern can be used to determine building heights and separation and provides the opportunity for reduce energy costs through improved daylighting and solar heat gain.

Likewise, an evergreen or a tree with dense foliage may be placed along a strong wind channel to help break or redirect the wind flow. Vegetation patterns, however, do not have to be limited to trees. Green spaces, such as parks, public greens, and swales are also important to vegetation design patterns as they provide locations for water storage and infiltration. By slowing or redirecting the flow of water, a more natural water flow cycle can occur. Swales located at the perimeter and edge of streets can act as an effective vegetation design pattern as they can help in water flow and storage. Existing neighborhoods with a high percentage of paved landscape can be improved with the addition of swales and green spaces. Thus vegetation patterns are beneficial to green neighborhoods when integrated with solar, wind, water system patterns.

Habitat

Defining city and neighborhood boundaries using existing land and urban features can help protect and enhance the natural environment. Conventional zoning regulations tend to neglect the natural environment and natural land features. The urban environment can not be dropped into the natural environment; it must be integrated with the natural environment. Habitat design patterns need to be integrated with urban design codes to help create this synthesis between man and nature. Ecological boundary patterns can be beneficial in this synthesis. For example, by creating a no build zone at a neighborhood’s 500 year floodplain and adding an extra fifty feet for parks and greenways, designer can help protect and regenerate the riparian buffer along creeks and rivers (fig. 15). This type of restriction should also include blue streams and steep slope conditions, offering an

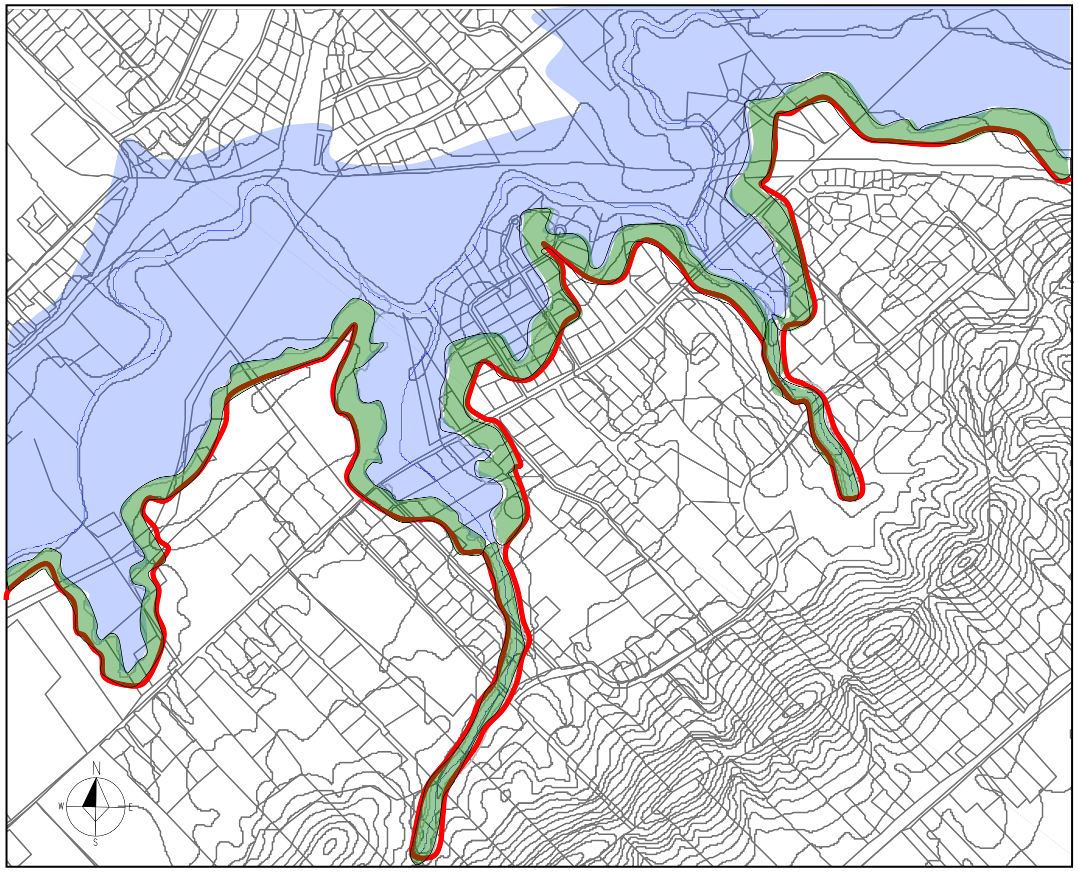

Figure 15: Blue Stream Preservation Pattern
The blue shaded area is the existing 500 year floodplain for the site used in this study. Conventional Neighborhood codes have set minimal restrictions for building within the 500 year floodplain and have no restrictions for building over blue streams, such as creeks, streams, and other manmade or naturally occurring water systems. To help protect and regenerate the riparian buffer along the creek network, a 50 ft. no build zone (Green Shaded) has been designed along the 500 year floodplain and the blue stream network. No building may occur within the 500 year floodplain or the 50 ft. buffer. Along the 50 ft. buffer a 25’ zone (Red Line) has been added to be used for parks and a greenway system. This is to further protect the creek and riparian buffer as well as promote social interaction through the use of parks and pedestrian streets.

opportunity for increased park space and more extensive greenway networks. Habitat design patterns based ecologically sensitive boundary restrictions, can help locate and define green neighborhoods. The habitat design pattern can also be an effective way of connecting neighborhoods using pedestrian green networks. By adding walking and biking trails along the ecological boundaries defined in the habitat design pattern, a green street network can be incorporated into a neighborhood street system. The health and energy conservation benefits that come with walking and biking make pedestrian streets a necessity to green neighborhoods.

Chapter 4

Integrating Ecological Design Patterns into Contemporary Neighborhoods

The Conventional and Contemporary Neighborhood

This study will integrate ecological design patterns into conventional and contemporary neighborhood codes and regulation. The purpose of applying the ecological design patterns to the codes and regulations of conventional and contemporary neighborhoods is to push urban planners and developers into using environmentally sensitive design techniques. In doing so, urban environments can be developed with strong ecological foundation beginning at the initial design phase. Before looking into the codes and regulations, it is worth recognizing existing urban patterns of development found in the planning of the conventional and contemporary neighborhoods.

The conventional neighborhood pattern is large residential lots with disconnected street networks and sprawling urban communities. This is a result of urban codes and regulations that focus on the developing of land as opposed to the planning of urban environments. This means that the codes do not restrict land use for the purpose of creating communities, but instead allows developers to purchase land to be used solely for monetary gain. A negative effect that results from the conventional neighborhood model is sprawling urban environments with an increased dependency on vehicular travel. Though vehicular travel cannot be avoided, neighborhoods that promote walking and biking for everyday needs can help in terms of energy costs and savings. This is a major downfall to the conventional neighborhood model.

In an effort to improve neighborhood designs, the New Urbanists, including Andres Duany and Elizabeth Plater-Zyberk, created the "*SmartCode*" (*SmartCode & Manual V8.0*). The *SmartCode* is an urban code and regulating guide that is used to design the contemporary neighborhood (fig. 16). By providing an intricate network of vehicular and pedestrian streets, and in corporating civic and mixed-income and use buildings, the contemporary model adds social and environmental design patterns missing in the conventional model. Though the contemporary model does promote pedestrian friendly streets and a dense urban fabric, it still lacks essential ecological system design patterns.

A sustainable development must include ecological design strategies formulated from ecological, social, and economic system patterns. The green neighborhood is the synthesis of contemporary urban codes and regulation integrated with design strategies created from ecological systems. This study will integrate ecological design strategies formulated from ecological system patterns into existing contemporary neighborhood codes and regulation to create a green neighborhood.

Urban Codes and Regulations

Conventional and contemporary neighborhood design is most commonly guided through a series of codes and regulations. These urban codes are used to control building placement, street and building dimensions, building materials, building uses and patterns

SMARTCODE **TABLE 14 SMARTCODE SUMMARY**

municipality

Note: All requirements in this Table are subject to calibration for local context.

R U R A L I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I U R B A N

DISTRICTS

	T1 NATURAL ZONE	T2 RURAL ZONE	T3 SUB-URBAN ZONE	T4 GENERAL URBAN ZONE	T5 URBAN CENTER ZONE	T6 URBAN CORE ZONE	SD SPECIAL DISTRICTS
A. ALLOCATION OF ZONES (see Section 3.1 and Table 2)							(see Table 15)
CLD	no minimum	50% MIN	10 - 30%	20 - 40%	prohibited		
TND	no minimum		10 - 30%	30 - 60 %	10 - 30%	prohibited	
RCD	no minimum		prohibited	10 - 30%	10 - 30%	40 - 80%	
TOD	no minimum		prohibited	0 - 30%	0 - 30%	40 - 100%	
B. BASE RESIDENTIAL DENSITY (see Section 3.4)							
By Right	1 unit / 100 ac. avg.	1 unit / 20 ac avg.	2 units / ac. gross	4 units / ac. gross	6 units / ac. gross	12 units / ac. gross	
By TDR	by Variance		6 units / ac. gross	12 units / ac. gross	24 units / ac. gross	96 units / ac. gross	
Other Functions	by Variance		10 - 20% min	20 - 30% min	30 - 50% min	50 - 70% min	
C. BLOCK SIZE							
Block Perimeter	no maximum		3000 ft. max	2400 ft. max	2000 ft. max	2000 ft. max *	
						* 3000 ft. max with parking structures	
D. PUBLIC FRONTAGES (see Tables 3 and 4)							
HW & RR	permitted			prohibited			
BV	prohibited		permitted				
SR	prohibited		permitted		prohibited		
RS	prohibited		permitted		prohibited		
SS & AV	prohibited				permitted		
CS & AV	prohibited				permitted		
Rear Lane	permitted				prohibited		
Rear Alley	prohibited		permitted	required			
Path	permitted				prohibited		
Passage	prohibited		permitted				
Bicycle Trail	permitted			prohibited *			
Bicycle Lane	permitted				prohibited		
Bicycle Route	permitted						
						* permitted within Open Spaces	
E. CIVIC SPACES (see Table 13)							
Park	permitted						
Green	prohibited		permitted			prohibited	
Square	prohibited			permitted			
Plaza	prohibited				permitted		
Playground	permitted						
F. LOT OCCUPATION							
Lot Width	by Variance	by Warrant	72 ft. min 120 ft. max	18 ft. min 96 ft. max	18 ft. min 180 ft. max	18 ft. min 700 ft. max	
Lot Coverage	by Variance	by Warrant	60% max	70% max	80% max	90% max	
G. BUILDING DISPOSITION							
Front Setback	by Variance	48 ft. min	24 ft. min	6 ft. min 18 ft. max	0 ft. min 12 ft. max	0 ft. min 12 ft. max	
Side Setback	by Variance	96 ft. min	12 ft. min	0 ft. total min	0 ft. min 24 ft. max	0 ft. min 24 ft. max	
Rear Setback	by Variance	96 ft. min	12 ft. min	3 ft. min *	3 ft. min *	0 ft. min	
						* or 15 ft. from center line of alley	
H. BUILDING TYPE (see Table 9)							
Edgeyard	permitted				prohibited		
Sideyard	prohibited			permitted		prohibited	
Rearyard	prohibited			permitted	permitted		
I. PRIVATE FRONTAGES (see Table 7)							
Common Yard	not applicable	permitted		prohibited			
Porch & Fence	not applicable	prohibited	permitted		prohibited		
Terrance or L.C.	not applicable	prohibited		permitted		prohibited	
Forecourt	not applicable	prohibited		permitted			
Stoop	not applicable	prohibited		permitted			
Shopfront & Awning	not applicable	prohibited		permitted			
Gallery	not applicable	prohibited		permitted			
Arcade	not applicable	prohibited			permitted		
J. BUILDING HEIGHT (see Table 8)							
Principal Building	not applicable	3 stories max		4 stories max, 2 min	6 stories max, 2 min	12 stories max, 2 min	
Outbuilding	not applicable	2 stories max		2 stories max	2 stories max	not applicable	
K. BUILDING FUNCTION (see Table 10 & 11)							
Residential	prohibited	restricted use		limited use	open use		
Lodging	prohibited	restricted use		limited use	open use		
Office	prohibited		restricted use	limited use	open use		
Retail	prohibited		restricted use	limited use	open use		

DISPOSITION

CONFIGURATION

FUNCTION

ARTICLE 5

ARTICLE 2, 3, 4

SC129

Figure 16: *SmartCode* Summary

This is a summary of the *SmartCode* that presents a series of codes and regulations based on population density levels. This study focuses on integrating ecological design codes and regulation into the T4 density level (*SmartCode & Manual*, 156).

of open space. The green neighborhood in this study integrates ecological design patterns into the urban codes in an effort to protect the natural systems that are affected through the creation of the urban environment. This is accomplished by restricting building construction in hazardous areas and incorporating passive system design through the placement and configuration of blocks, lots, streets, buildings, trees and open spaces. A regulating plan is the first tool used in this process. The regulating plan defines building and street zoning at the neighborhood scale as related to the urban codes (fig. 17). Once a building or street zone is chosen to be developed, the urban codes provide the guidelines for developing the “lot” and the “block”. The lot and block codes pertain to detailed street and building components, i.e. building height, use and setback dimensions, vehicular and pedestrian street dimensions, trees and vegetation types, water runoff and drainage patterns, and building materials and orientation (fig. 18). The contemporary *SmartCode* model prescribes lot and block dimensions based on patterns from traditional neighborhoods. Specific patterns of the contemporary model are an intricate pedestrian and vehicular street network, a ¼ mile radius neighborhood boundary, building height restriction based on specified zoning within the neighborhood boundary, and an emphasis on mixed-use and mixed income housing located around a defined neighborhood center. The codes that regulate the contemporary neighborhood offer a starting point for the design of the green neighborhood in this study.

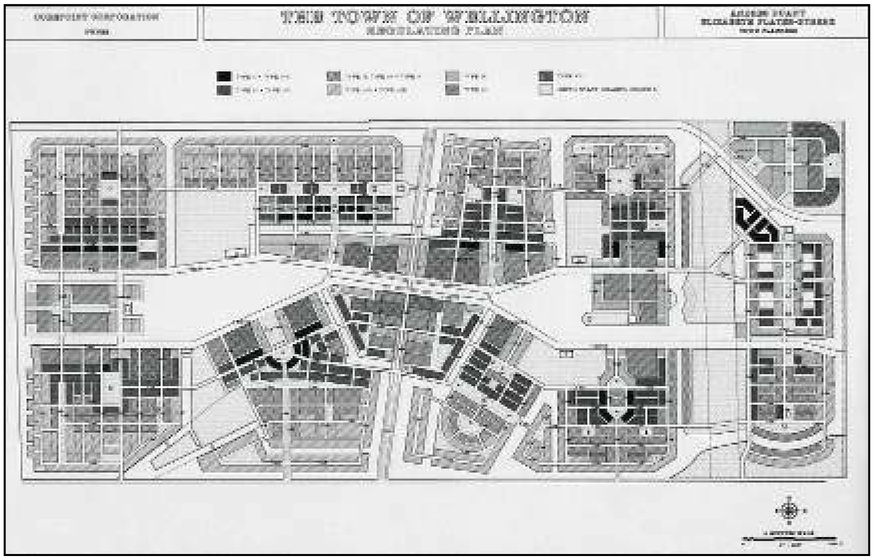

Figure 17: Regulating Plan for The Town Of Wellington
This is a regulating plan taken from *The New Urbanism* (Katz, 110). The regulating plan is used to identify urban zones as related to a series of building codes. This allows for the establishment of housing density and building use patterns within an urban development.

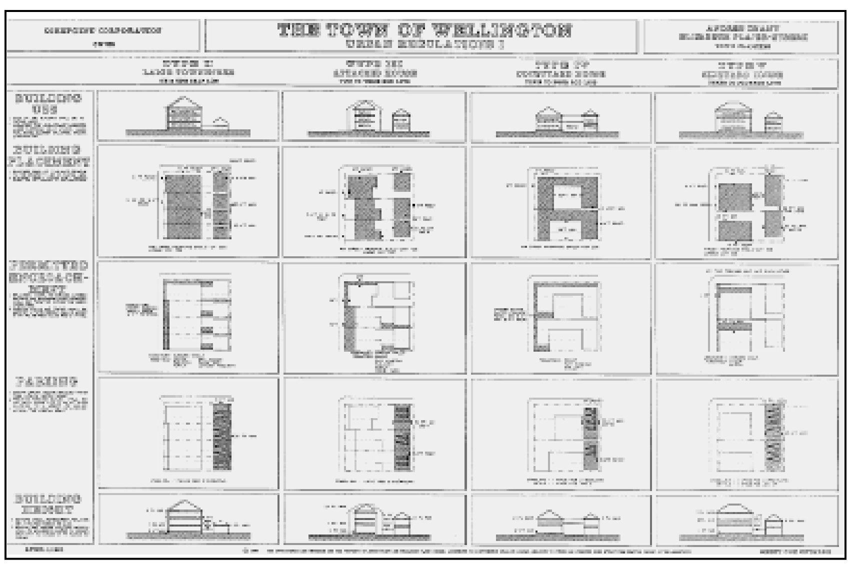

Figure 18: Urban Regulations for The Town Of Wellington
This image presents a series of urban codes taken from *The New Urbanism* (Katz, 111). These codes relate to a corresponding regulating plan and are used to regulate building heights, setbacks, and uses.

The Green Neighborhood

To create green neighborhoods, ecological design patterns need to be integrated into the contemporary urban code matrix. The contemporary model places a strong emphasis on community development and architectural design. With the addition of ecological design patterns, the contemporary codes offer the foundation for creating sustainable developments. For example, by integrating wind flow patterns into the *SmartCode*, the contemporary neighborhood could be designed to provide sufficient air flow through lot, the block and the whole neighborhood. Likewise, sun and shade patterns can be used to reformulate building and tree codes based on orientation, size, and type to provide sufficient heating and cooling within a neighborhood. By integrating ecological design patterns into the contemporary neighborhood codes, a set of urban regulations can be established that help push urban design towards sustainable development. Though a truly self-sustaining urban environment is not completely practical or easily attainable, the green neighborhood represents a step in the right direction. The green neighborhood utilizes contemporary design techniques with ecological patterns in an effort to promote social wellbeing, a unique architectural and urban character, and energy savings at both the individual and community scale. This study will apply contemporary codes integrated with ecological design patterns to an existing site in order to create a green neighborhood.

Chapter 5

The Powell Green Neighborhood

Powell Green Neighborhood

To further analyze the patterns for creating green neighborhoods, a series of urban codes have been formulated through the combination of contemporary design codes and ecological systems patterns, then implemented a proposal for an existing site located in Powell, Tennessee.

Powell Site Analysis

The site chosen for this study is a 103 acre sprawling community located in Powell, Tennessee. There are currently 91 existing single family homes built on the site with five existing roads (fig. 19). The physical boundaries that contain the site are Beaver Ridge to the south, West Beaver Creek Drive to the north, Crowns Community College to the West, and Oakmeade Road to the East (fig. 20 & 21). A quarter mile radius boundary has also been set in accordance with the contemporary design model's size for a neighborhood. This quarter mile radius is met within the physical boundaries stated above. This site was chosen because of its proximity to specific geological features, which include Beaver Ridge and Beaver Creek, and its current economic and social conditions as affected by local codes and regulations; specifically a sprawling, low density development. The building codes for Powell are regulated by Knox County Master Planning Commission. These codes place no maximum restriction on lot sizes,

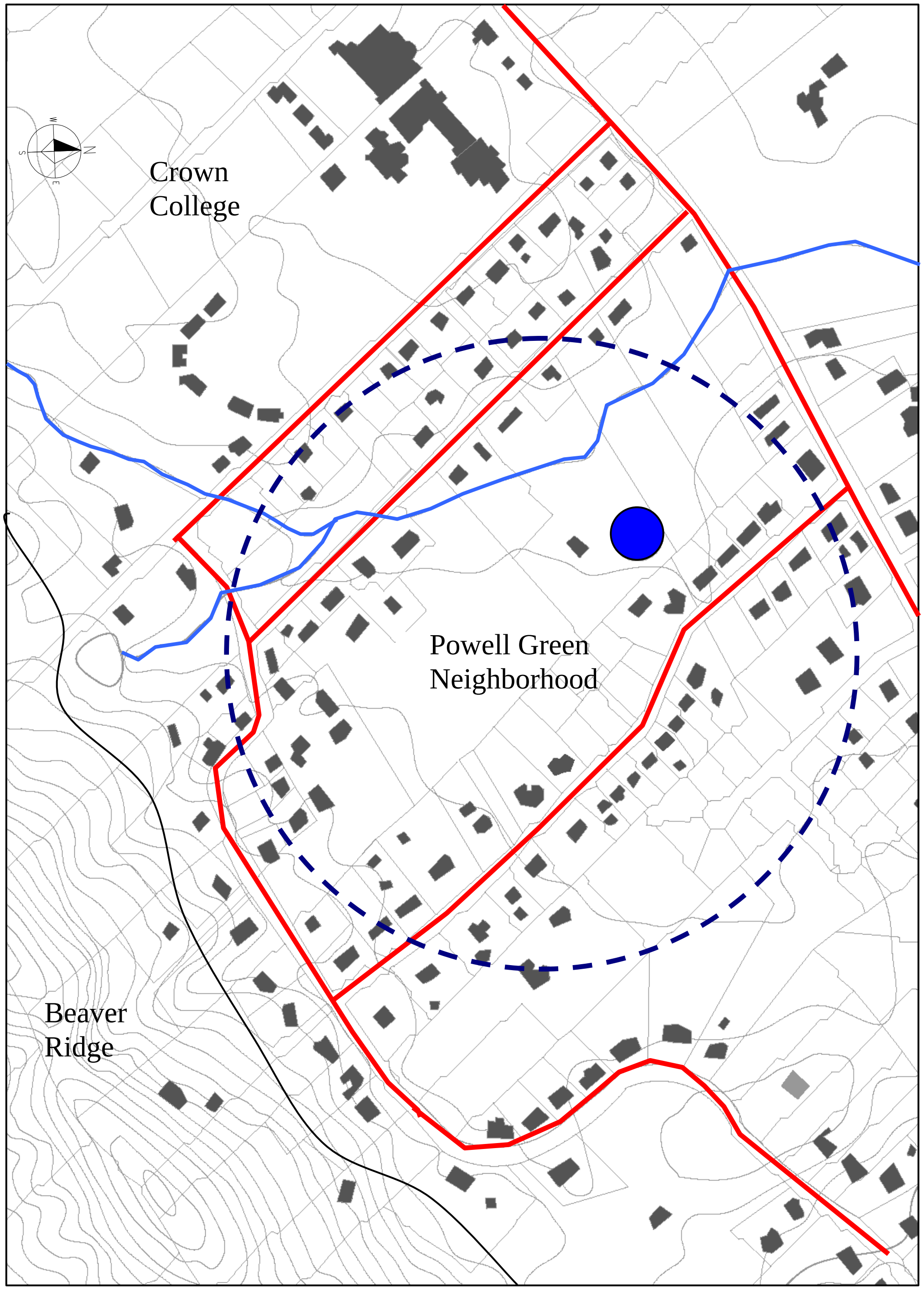

Figure 19: Powell Site With Street Network
This map shows the existing building and infrastructure of the Powell, Tennessee site used in this study. The dashed blue line represents the ¼ mile radius development boundary as defined by *SmartCode*. The dark boxes represent the existing homes and the red line demarks the existing roads. The blue lines represent a branch of Beaver Creek that cuts through the site, while the blue circle shows an existing pond. The lighter gray lines map existing topography and lot lines.

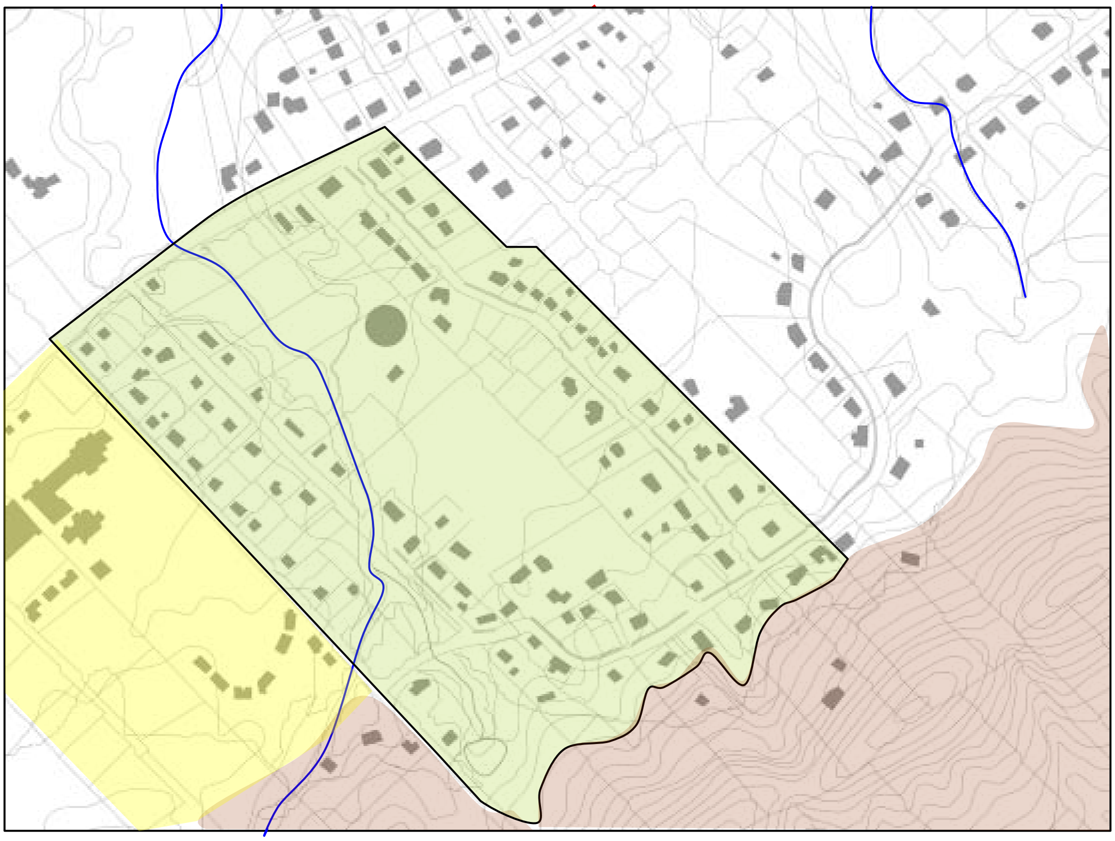

Figure 20: Powell Site

This map shows the boundaries that define the site used in this study. The dashed blue line represents the ¼ mile radius development boundary as defined by *SmartCode*. The thick red line shows West Beaver Creek Drive at the north end of the site and the thin red line shows Oakmeade Road to the east side of the site. The yellow highlighted area shows an existing community college on the west side of the site. The brown highlighted area to the south shows the Beaver Ridge as its slope grows steeper than fifteen percent. The solid blue line represents branch streams of Beaver Creek that cut through the western side of the site. The green highlighted area represents the existing site.

Figure 21: Powell Site Arial Photograph
This Image shows the boundaries which define the Powell Neighborhood site (Google Earth). Similar to the previous figure, the green highlighted area represents the existing site. The red lines show the existing street network within the site and the blue dashed line represents the ¼ mile radius boundary as defined by *SmartCode*.

offer limited incentive for building mixed-use establishments, and have no protection for ecological systems such as streams, riparian buffers, and steep slopes. Similarly, the code does nothing to discourage a sprawling urban environment. This lack of urban morphology fit to environmental systems has offered an opportunity to create an amended version of the contemporary urban code. This amended version is created by integrating the *SmartCode* with new ecological design patterns into a modified Knox County code matrix. The Powell green neighborhood in this study has been designed using the amended code.

Powell Green Neighborhood Program

Developing the program for the Powell Green Neighborhood began by integrating contemporary neighborhood guidelines, as taken from the *SmartCode,* with the conventional Knox County codes and regulations. The contemporary neighborhood model calls for a gross building density of four buildings per acre. This requirement was used to determine a minimum gross density of 412 housing units in the Powell Green Neighborhood. Of the 412 units, *SmartCode* promotes the design of mixed-use and higher density building types. The Powell Green Neighborhood building program has been broken down into six types: Mixed-Use, Townhouse/Row house, Single Story Duplex, Two Story Duplex, Single Family 0-15% slope, and Single Family 15-25% slope (table 1). The Mixed-Use building type makes up the smallest portion of the neighborhood program, because the Powell Green Neighborhood is not a business center. However, the Mixed-Use buildings are located at the center of the neighborhood and offer commercial services within five minute walking distance to any home in the

Table 1: Building types and percentages to be used in the Powell Green Neighborhood.

Powell Green Housing Type	Zone (Units per acre)	Number of Units	Ave. # of Families (Ave. # of Family Members) / Number of Inhabitants	Percent of Building Neighborhood Occupancy
Mixed Use	**I (13)**	12	4.5(2) / 108	5%
Townhouse/Row house	**I (13)**	147	2.5 (2.5) / 919	47%
Single Story Duplex	**II (10)**	52	2 (2.5) / 260	13%
Two Story Duplex	**II (10)**	32	2 (2.5) / 160	8%
Single Family 0-15% Slope /Existing	**III (6)**	57/69	1(3) / 378	20%
Single Family 15-25% Slope /Existing	**IV (4)**	22/22	1 (3) / 132	7%
Total	**I-IV**	413	1957	100%

neighborhood. Surrounding the central district of the neighborhood is the higher density housing. The higher density building types, apartment and mixed use buildings, make up the largest percentage of the neighborhood building program. The Powell Green neighborhood promotes the traditional and contemporary design technique of mixed-use and medium density housing as a way of encouraging pedestrian interaction and a reduction in automobile dependency. This neighborhood design strategy is beneficial to the environment as well as social and economic growth. The final building type is the single family type, which defines the perimeter of the neighborhood. The Powell Green Neighborhood has been designed to preserve the existing single family homes while doubling the number of single family buildings. There are two single family housing types: the single family 0-15% slope and the single family 15-25% slope. These building types have been determined based on slope patterns. In an effort to preserve forest and slope conditions, the housing density and building types have been restricted in steep ridge zones. The 0-15% slope zone is restricted to single family buildings with a gross density of six buildings per acre. The 15-25% slope zone is restricted to single family buildings with a gross density of 4 buildings per acre. The restricted single family perimeter has been designed to protect the Beaver Ridge and Beaver Creek riparian buffer by reducing construction and building impact.

Softscape type patterns are another integral part of the Green Neighborhood program (table 2). The percentage of area dedicated to parks and green spaces was determined based on already existing softscape zones, the analysis of water runoff and infiltration, and design criteria found in *SmartCode*. At the center of the neighborhood is the Powell

Table 2: Softscape type and percentages to be used in the Powell Green Neighborhood.

Powell Softscape Type	# of Acres	Approximate Percentage of Site
Neighborhood Green Center	.9 Acres	1%
Community Green	2.8 Acres	2.5%
Park	3.8 Acres	3.5%
Blue Stream + 500 Year Buffer Zone	31 Acres	31%
Total	38.3	38%

square. The square defines the center of the neighborhood and acts as a beacon for social interaction, while providing a source of water infiltration and return to the Beaver Creek water system. Similar points of infiltration are located throughout the site. Points of infiltration were determined using the water system pattern formulated through the analysis of water flow through the site and have been designed into park and community green spaces (fig. 22). The final softscape type is the Beaver Creek stream system and 500 year flood buffer zone. Local codes place no restrictions on blue streams or the preservation of riparian buffers. The Powell Green Neighborhood has been designed to help preserve these ecological features by placing stronger building restrictions, as evolved from ecological patterns into neighborhood design strategies, around the Beaver Creek blue streams and the 500 year floodplain. In doing so, a softscape buffer zone is created that is to be used for greenways and parks, as well as the regeneration of the riparian buffer.

Powell Green Neighborhood Ecological Design Patterns

The ecological design patterns formulated for the Powell Green Neighborhood are based on water flow, wind, green space and vegetation, daylight and shading, and slope and density systems. Each pattern has been articulated into a design element used in the creation of the Powell Green Neighborhood. The first pattern used is the Breezy Streets pattern (fig. 23). This pattern is given in Sun, Wind, and Light (Brown & DeKay, pg.115) and was used to determine the street layout for the neighborhood (fig. 24). By aligning the streets to the designated orientation, wind flow can be guided through the site helping cool streets and building in the summer and provide better air circulation. The next

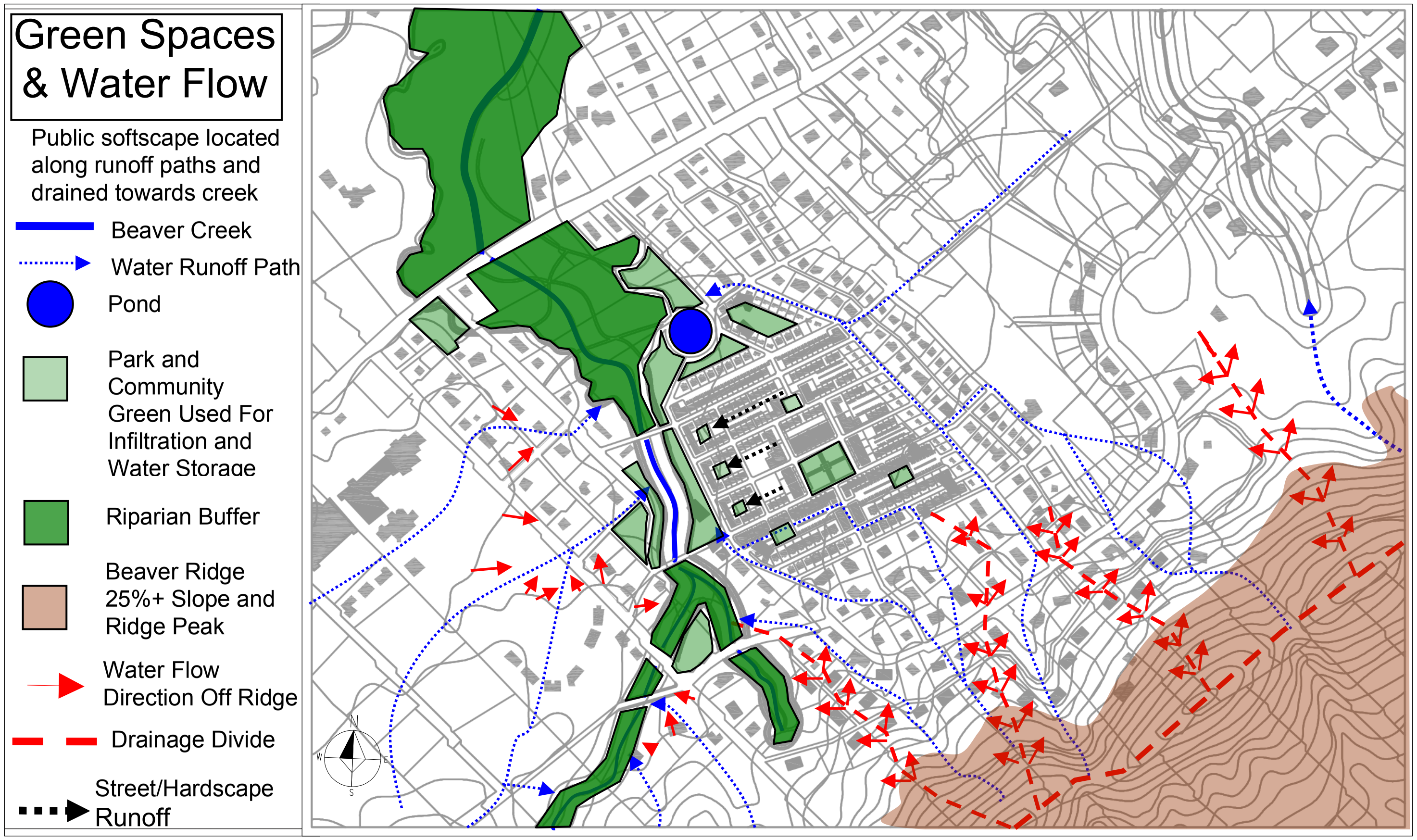

Figure 22: Water System Pattern
The green spaces and water flow pattern was used to determine the most logical points of infiltration and water drainage. By doing this, a water flow network was created that more efficiently returns runoff to the Powell Neighborhood watershed. Refer to green spaces and water flow pattern Figure 30.

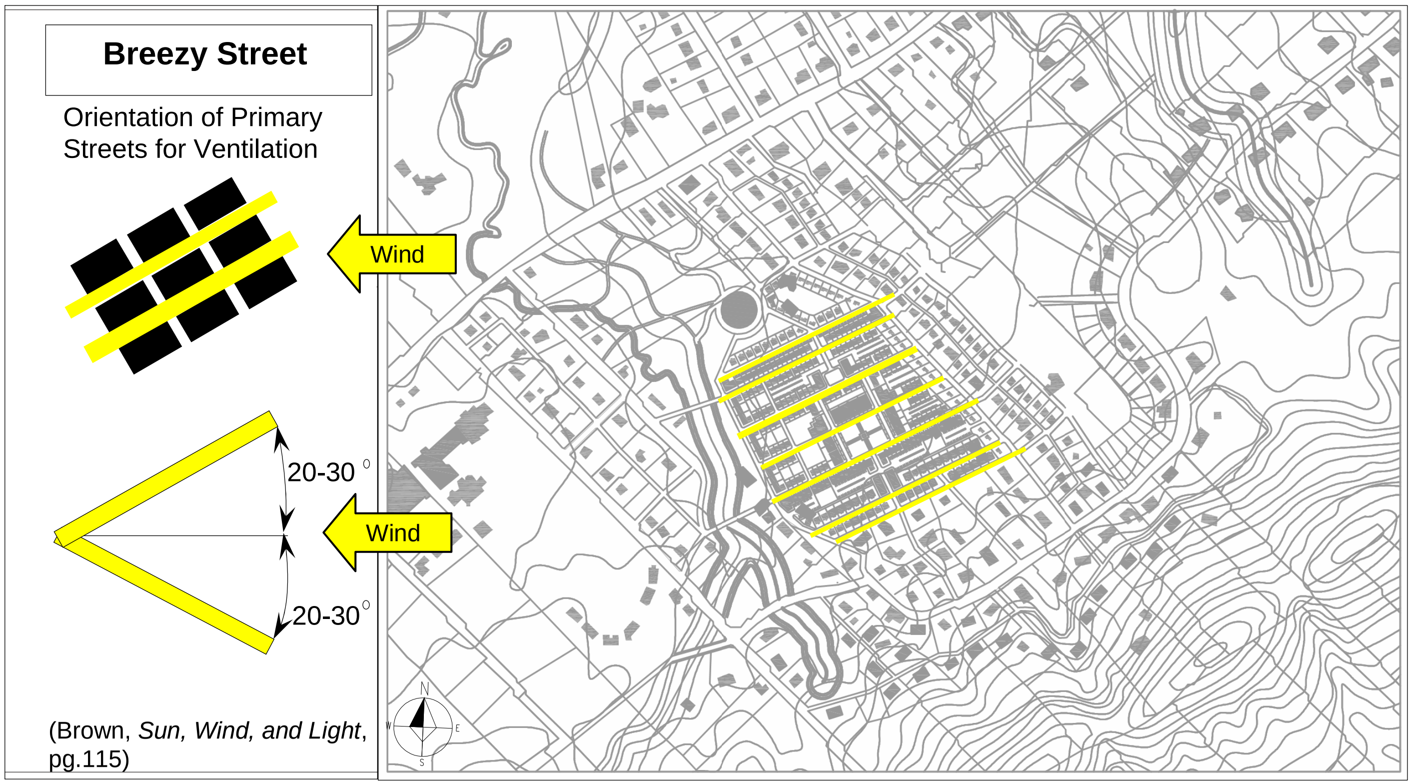

Figure 23: Breezy Streets Pattern
This is the Breezy Street pattern taken from Sun, Wind, and Light (Brown & DeKay, pg.115). By analyzing and mapping prevailing wind flow patterns through a site, streets can be oriented to more efficiently channel wind through a neighborhood. Benefits from this pattern include cooler streets and buildings in the summer months and improved air circulation throughout the site.

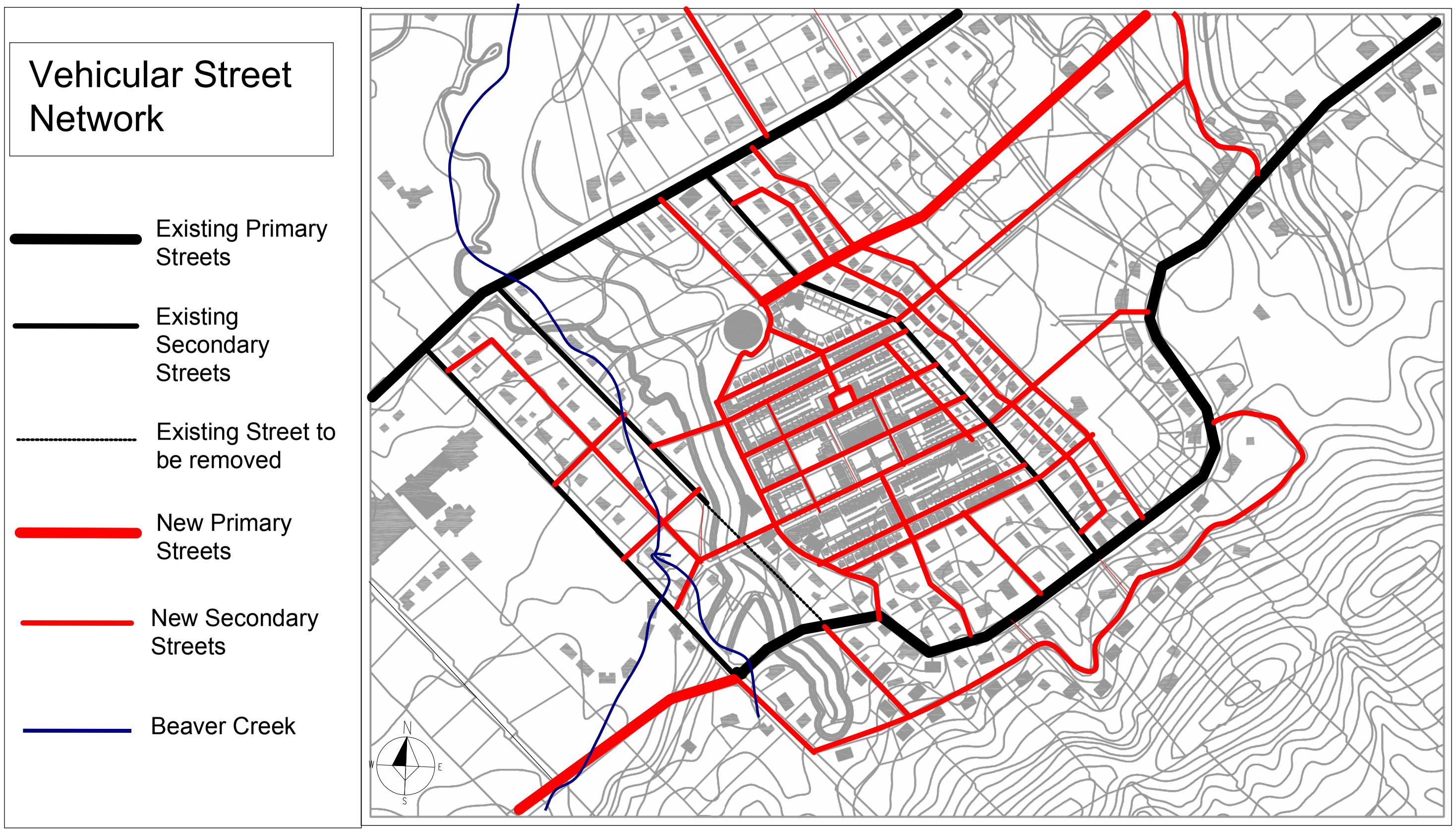

Figure 24: Vehicular Street Network
The vehicular street network pattern was developed using both the Breezy Streets pattern and the contemporary neighborhood intricate network of streets model. The new streets have been designed to provide more efficient vehicular circulation and to reduce the impact of roads on the Beaver Creek water system. To further improve the beaver creek water system through the site, vehicular bridges have been designed over both major and minor water ways and existing roads that directly impact the creek system have been removed.

pattern is the Daylighting and Shading pattern. This is another pattern taken from Sun, Wind, and Light (Brown & DeKay, Sun, Wind, and Light, pg.119) that was used to determine building spacing and layout (fig. 25). This pattern provides buildings with sufficient daylighting and shading, helping to reduce energy use and costs. The shading pattern has also been incorporated into a 3-d computer model to help analyze shading patterns cast from the building masses on the site (fig. 26). The next pattern is the Slope and Density pattern (fig. 27). This pattern regulates building construction along the beaver Ridge in an effort to preserve and regenerate forest and slope conditions. The Green Space and Vegetation pattern has been designed based on wind flow systems and sun and shading systems (fig. 28 and 29). This pattern regulates the use of different tree types based on solar orientation, to provide sufficient shading, and on wind flow to act as wind breakers (table 3). The final ecological design pattern is the Green Spaces and Water Flow pattern (fig. 30). This pattern has been formulated based on the Powell water flow system and has been used to locate points of water infiltration, storage and drainage. By providing the site with green spaces used for water infiltration and drainage based on water flow patterns, a network can be created that helps return water runoff more efficiently along the Beaver Creek system.

Powell Green Neighborhood Final Design

The final design of the Powell Green Neighborhood is based on the articulation of the ecological design patterns into an architectural and urban design language. As stated in this study, the process of creating the green neighborhood must occur through the urban

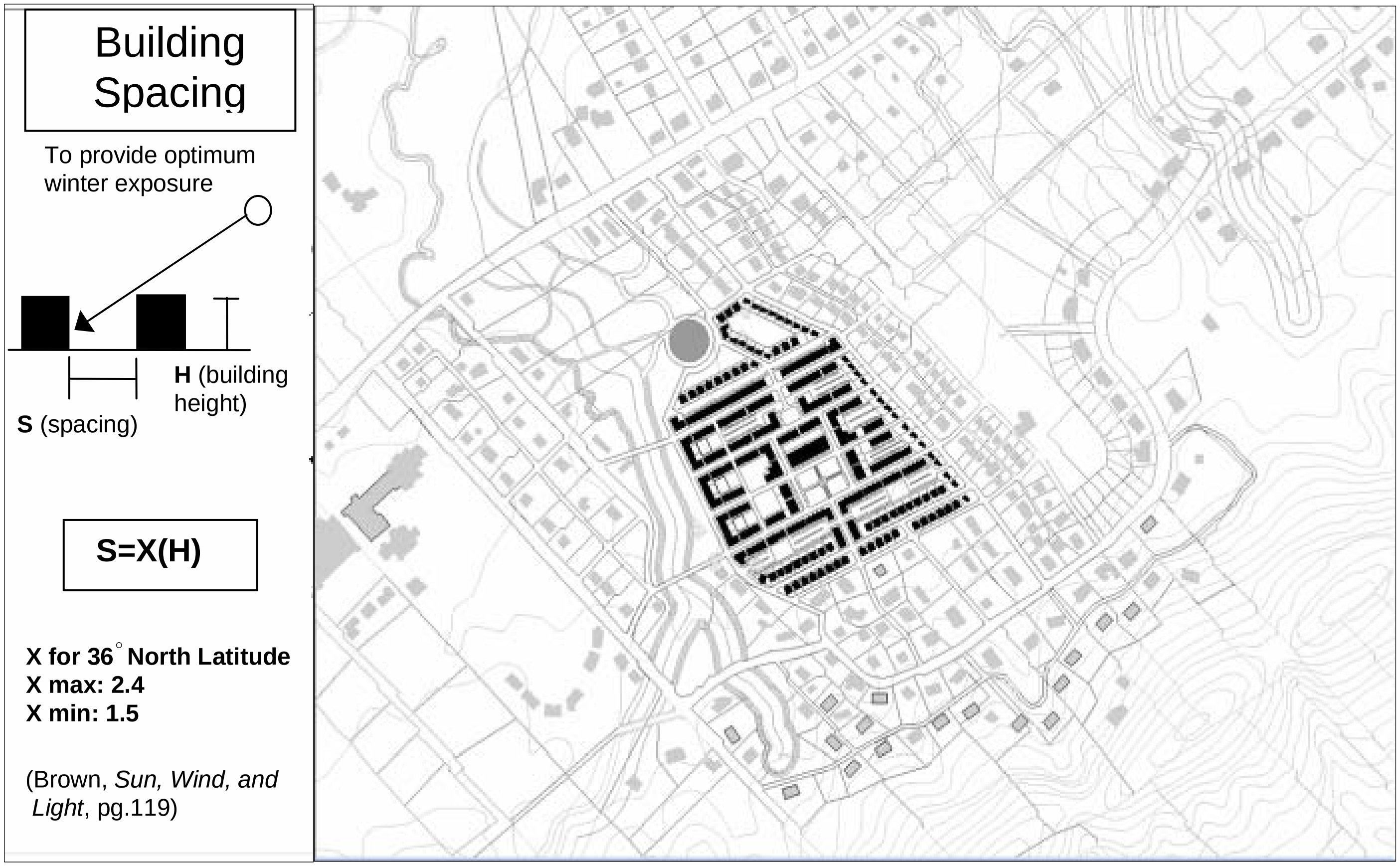

Figure 25: Daylight and Shading Pattern
The building spacing pattern is a sun and shading pattern taken from Sun, Wind, and Light (Brown & DeKay, pg.119). By staying within the maximum and minimum x values, buildings could be strategically located within the Powell Neighborhood to provide sufficient daylighting and shading, helping to reduce energy use and costs. The pattern was further integrated into the urban codes and regulation in the form of setbacks and building heights, offering a method of regulating ecologically responsive patterns in contemporary neighborhood design.

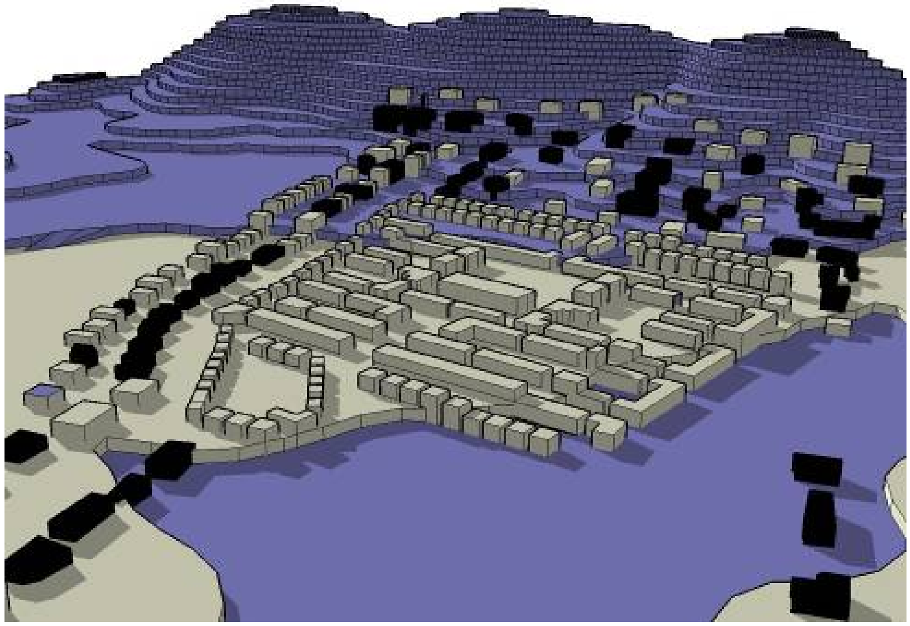

Figure 26: Daylight and Shading Study
Both images are from a shading analysis program used in this study to help locate buildings within the Powell Green Neighborhood. The buildings masses have be sized, spaced, and oriented based on the analysis of shading patterns at different times of the year in Powell, Tennesee, while still maintaining density patterns as described in *SmartCode*. The top image shows the building shadows cast at 12:00 PM in December, while the bottom image is representative of the buildings shadows cast at 7:00 AM in June.

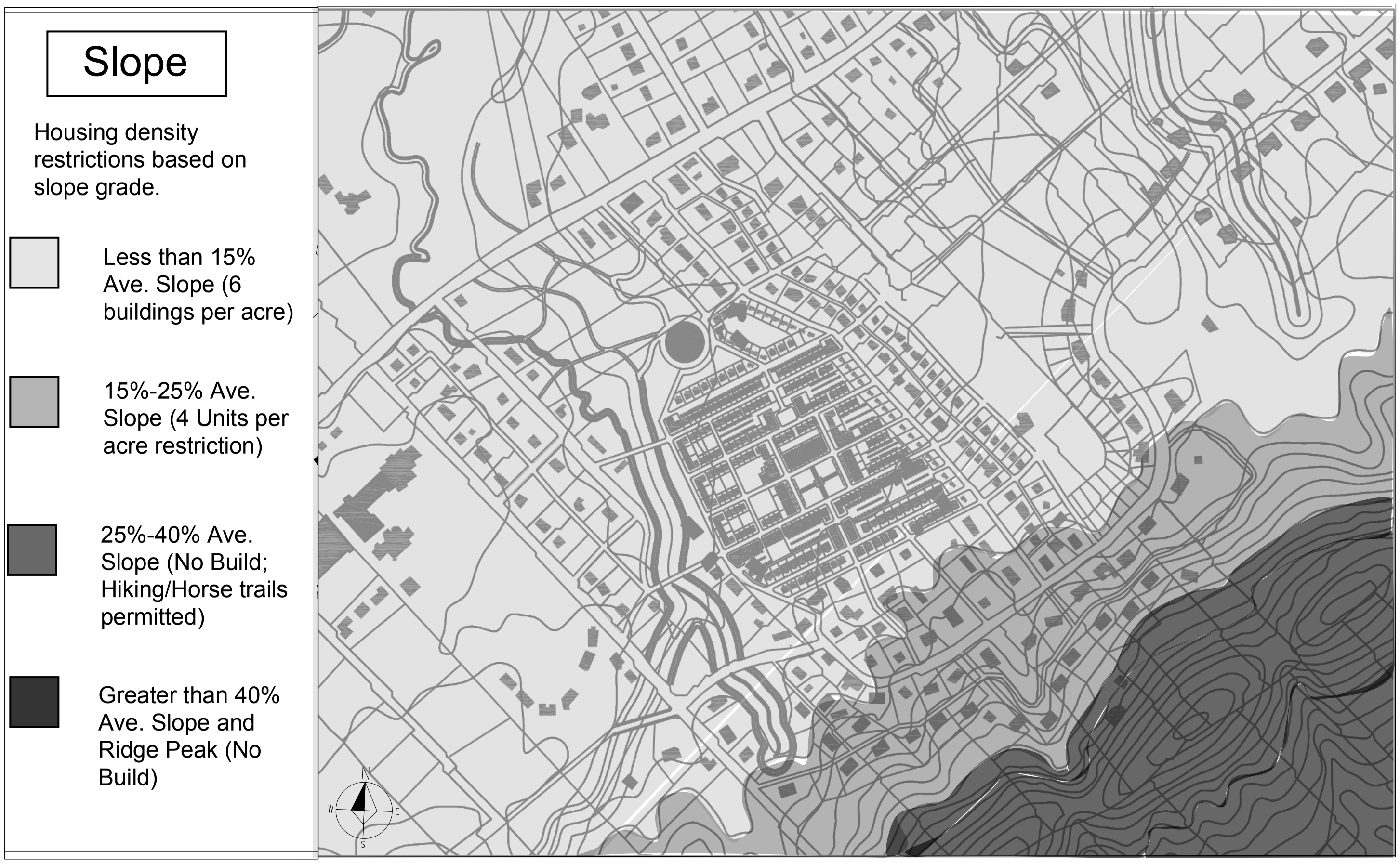

Figure 27: Slope and Density Pattern
The slope pattern maps topographic changes throughout the site and can be used to regulate building construction and density patterns. Regulating construction along the Beaver Ridge will help in the preservation and regeneration of exiting vegetation, slope, and water flow systems. This pattern was used in this study to locate building types and regulate land use based on different slope conditions. It was also integrated into the Powell Green Neighborhood Urban code to further enforce the green design strategy.

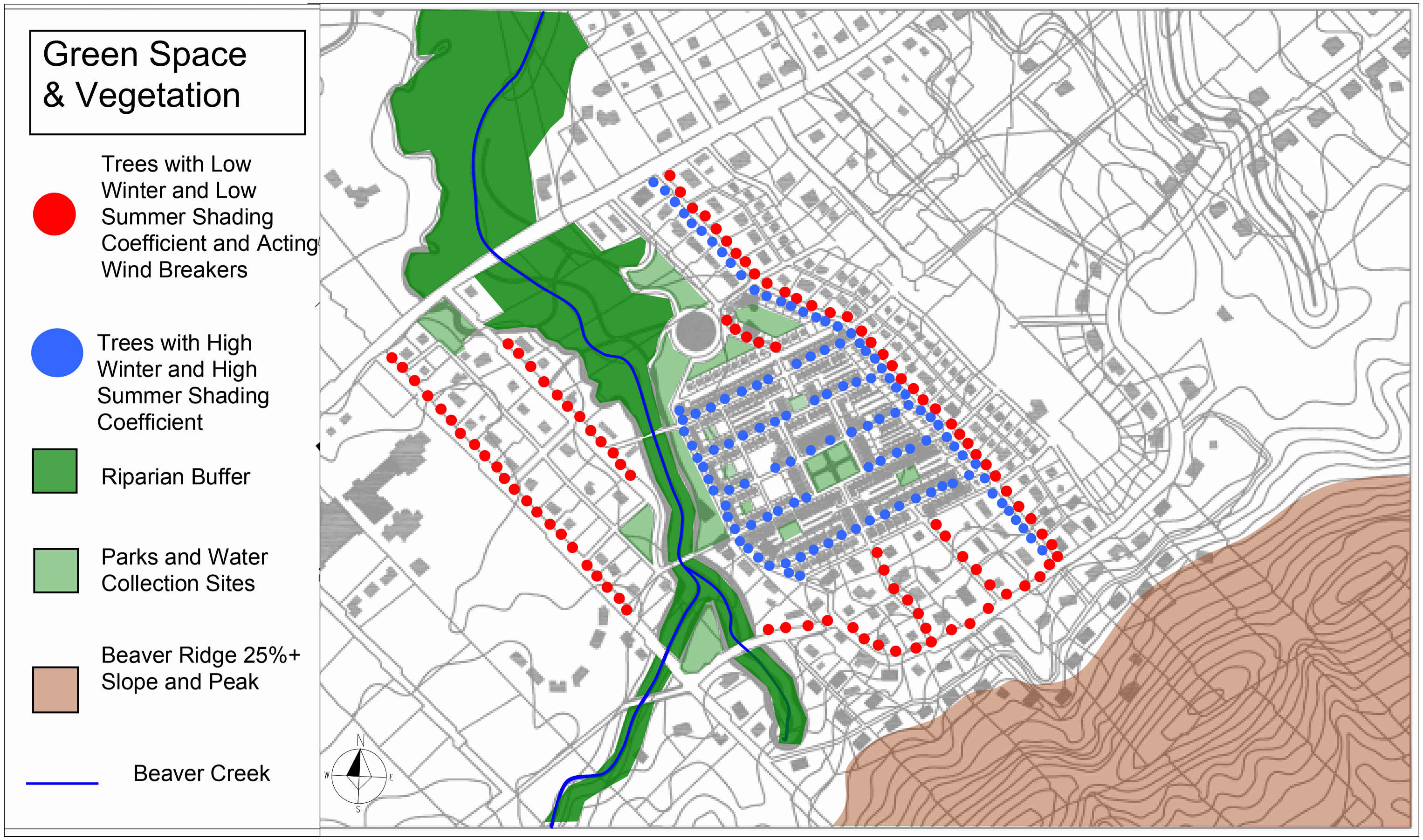

Figure 28: Green Space and Vegetation Pattern
The Green Space & Vegetation Pattern can be used to regulate different tree types based on solar orientation and prevailing wind flow patterns. As a neighborhood design strategy, trees should be used to break up cold winter winds or provide buildings with sufficient shading. The vegetation pattern has been integrated into the Powell Green Neighborhood codes and regulations.

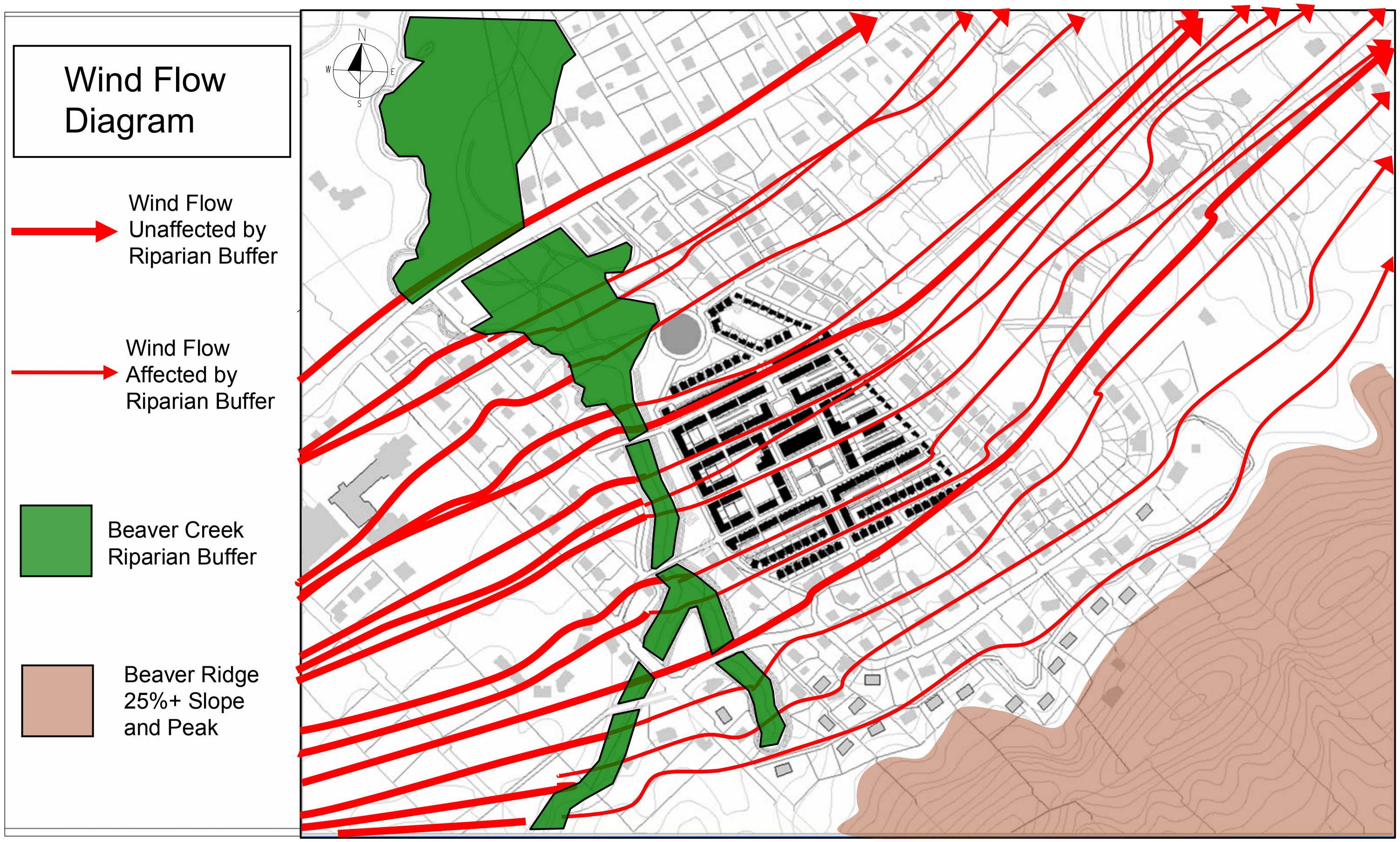

Figure 29: Wind Flow Diagram
The wind flow diagram demonstrates prevailing wind patterns through the Powell Neighborhood as affected by both natural and manmade structures. The diagram was used to develop both the green space and vegetation pattern as well as building and street orientation.

Table 3: List of Tree types to be used in Powell Green Neighborhood.

Tree Name	Mature Ht. ft	Winter Shading Coefficient	Summer Shading Coefficient	Street Type
Red Maple	75-100	.63-.82	.17	P- I II,III,IV V-II,IV
Green Ash	50-75	.70-.71	.13-.20	P- I II,III,IV
Tulip Poplar	75-100	..69-.78	.10	P- I II,III,IV
Sweet Gum	75-100	.65-.84	.18	P- I II,III,IV
Eastern Red Cedar	10-50'	NA	NA	P-I, II V-II, IV
Flowering Dogwood	35-50	.53	.43	P-I V-II,III,IV
Hawthorn, Washington	25-30	-----	.25	P-I V-II
Eastern Red Bud	20-35	.74	.62	P-I V-II,III

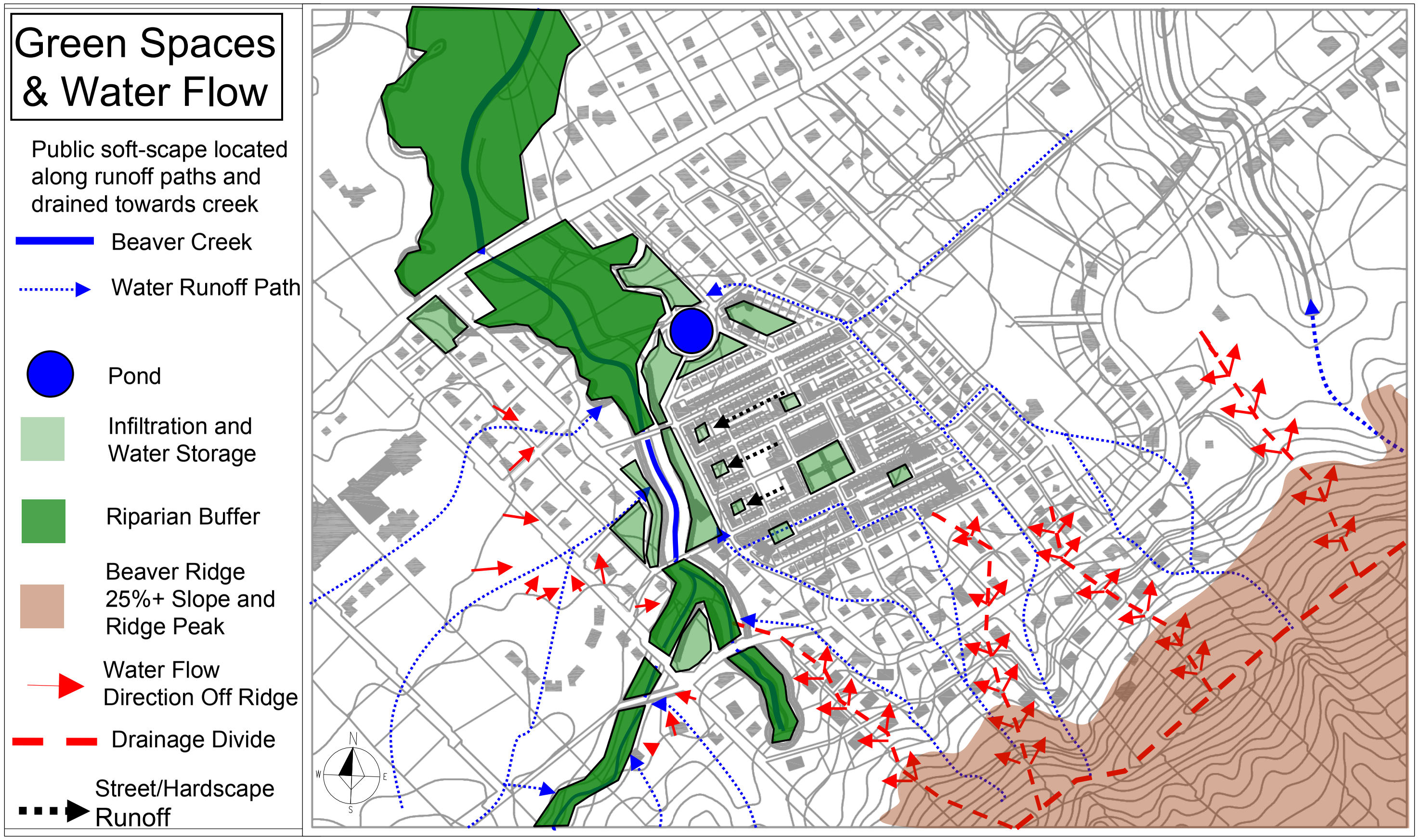

Figure 30: Water System Pattern
The water flow pattern was used to determine the most logical points of infiltration and water storage. This was accomplished by mapping existing water flow patterns and determining how the new neighborhood design would affect these patterns. By manipulating the neighborhood design to mimic existing water flow patterns, water could be channeled and redistributed more efficiently to infiltration and water storage sources.

codes that regulate neighborhood development. By integrating the ecological design patterns into contemporary neighborhood design methodologies, a new green neighborhood aesthetic can be created. The master plan for the green neighborhood demonstrates the overall composition of the design process (fig 31). The plan shows the multiple layers of softscape and building types as determined using the ecological patterns as well as contemporary neighborhood codes and principles. Ecological patterns have also been used to create a vehicular and pedestrian street network that gives the Powell Green neighborhood its own unique character (fig 32). Though the master plan demonstrates the overall composition of the site, it is the regulating plan that shows the site's break down as related to the corresponding urban codes (fig. 33). The Powell Green Neighborhood codes and regulations are unique in that they incorporate the ecological design patterns. This is done by amending the existing codes to regulate building design as necessary to accommodate the ecological patterns. Examples of this are organizing building spacing to provide efficient sun, shading, and wind flow as written into the urban regulations (fig 34 and 35). Similarly, a series of street type regulations have been formulated using contemporary neighborhood street type models with the addition of environmentally sensitive codes (fig 36-38). The amended codes and regulation have been integrated into the neighborhood design, articulating the environmental design patterns into an architectural language. This language has been further developed into a series of neighborhood plans and sections (fig. 39-44). It is through these neighborhood drawings that ecological design patterns are finalized into architectural form.

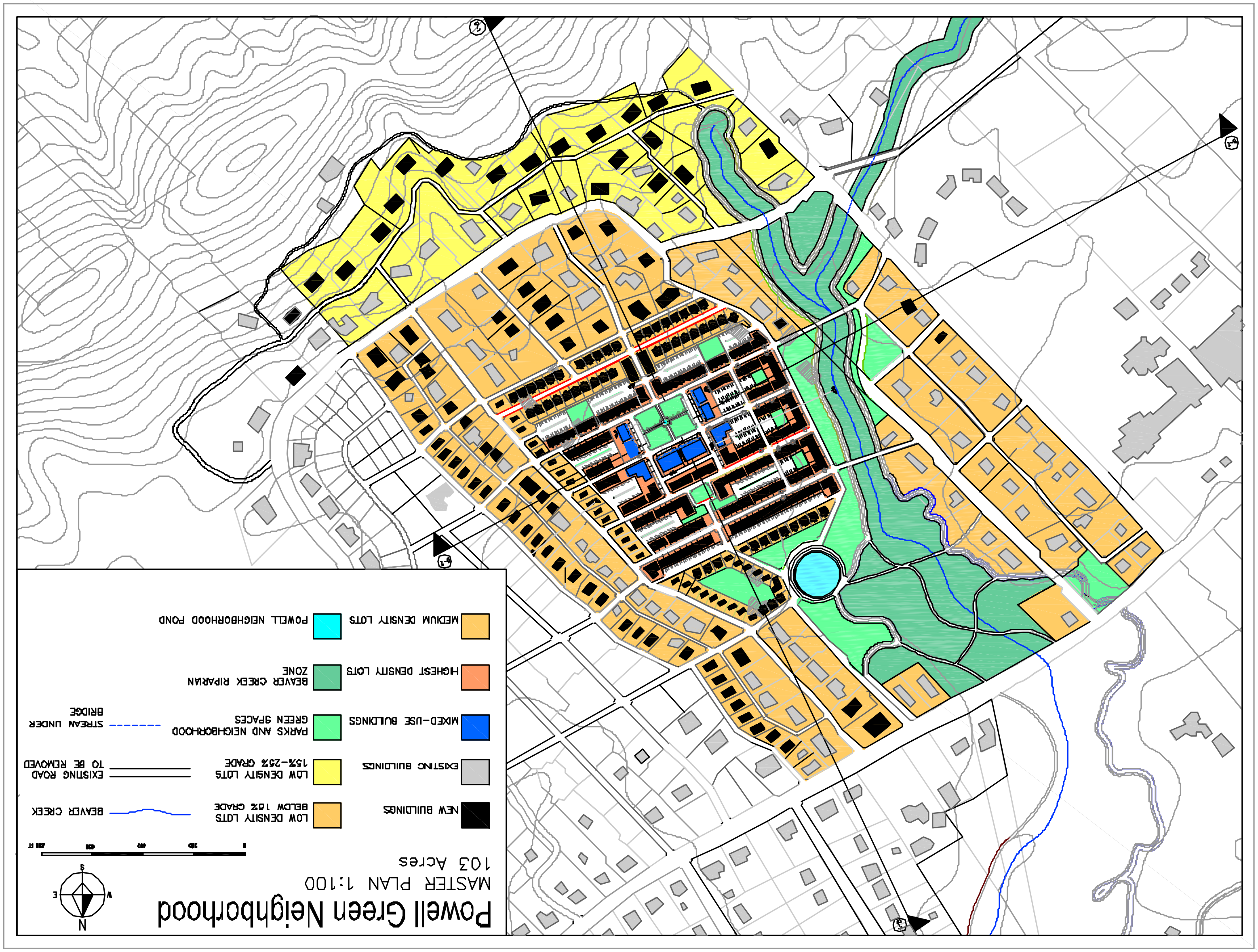

Figure 31: Powell Green Neighborhood Master Plan
The master plan shows the overall composition of the Powell Green Neighborhood as it denotes the location and allocation of different building types, population density zones, hardscape and softscape zones, pedestrian and vehicular streets, and highlights the neighborhood boundaries.

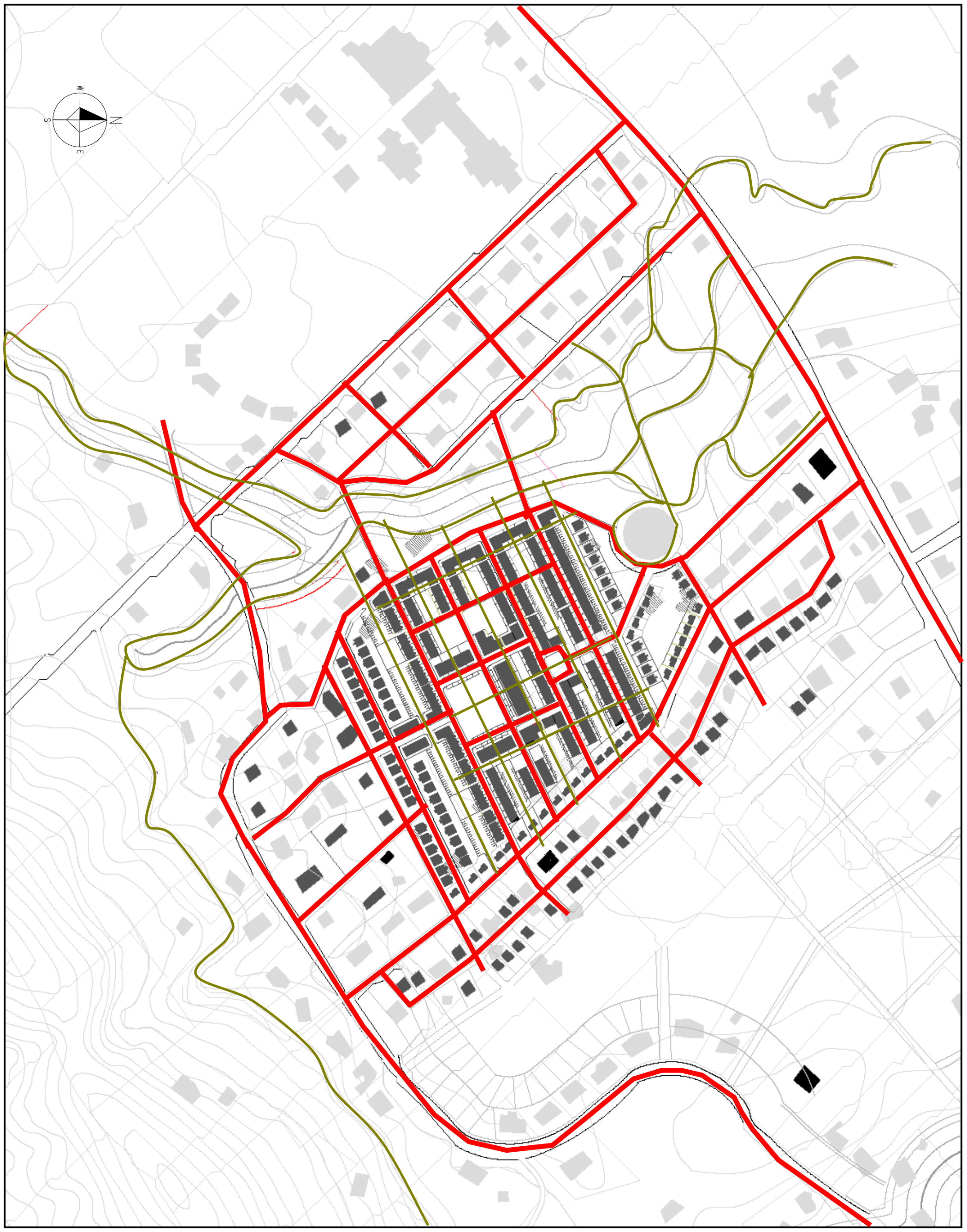

Figure 32: Powell Green Neighborhood Street Network
The Powell Neighborhood street network was developed using the breezy streets pattern and the contemporary neighborhood intricate network of street model. The dark boxes represent new buildings, while the lighter gray boxes represent existing buildings. The red line represents the new vehicular street network and the green lines represent the new pedestrian streets and greenway. Note that the vehicular streets have been designed with sidewalks to further promote walking and biking.

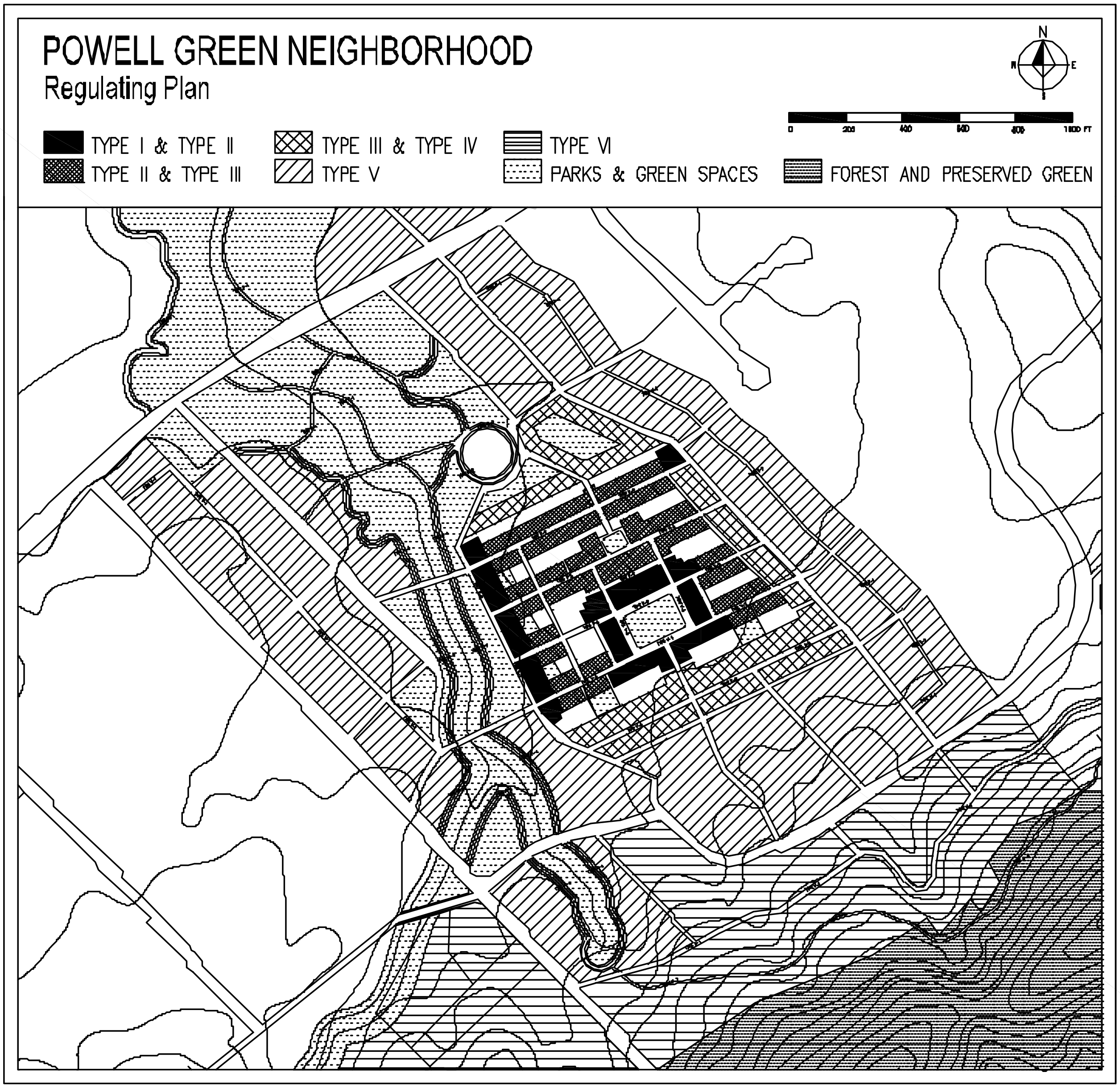

Figure 33: Powell Green Neighborhood Regulating Plan
The regulating plan relates to the urban codes set for the Powell Green Neighborhood and breaks down the site into different zones. The regulating plan also relates to and breaks down the street codes created for the Neighborhood. See figures 34-38, urban regulations and street types, for zone details.

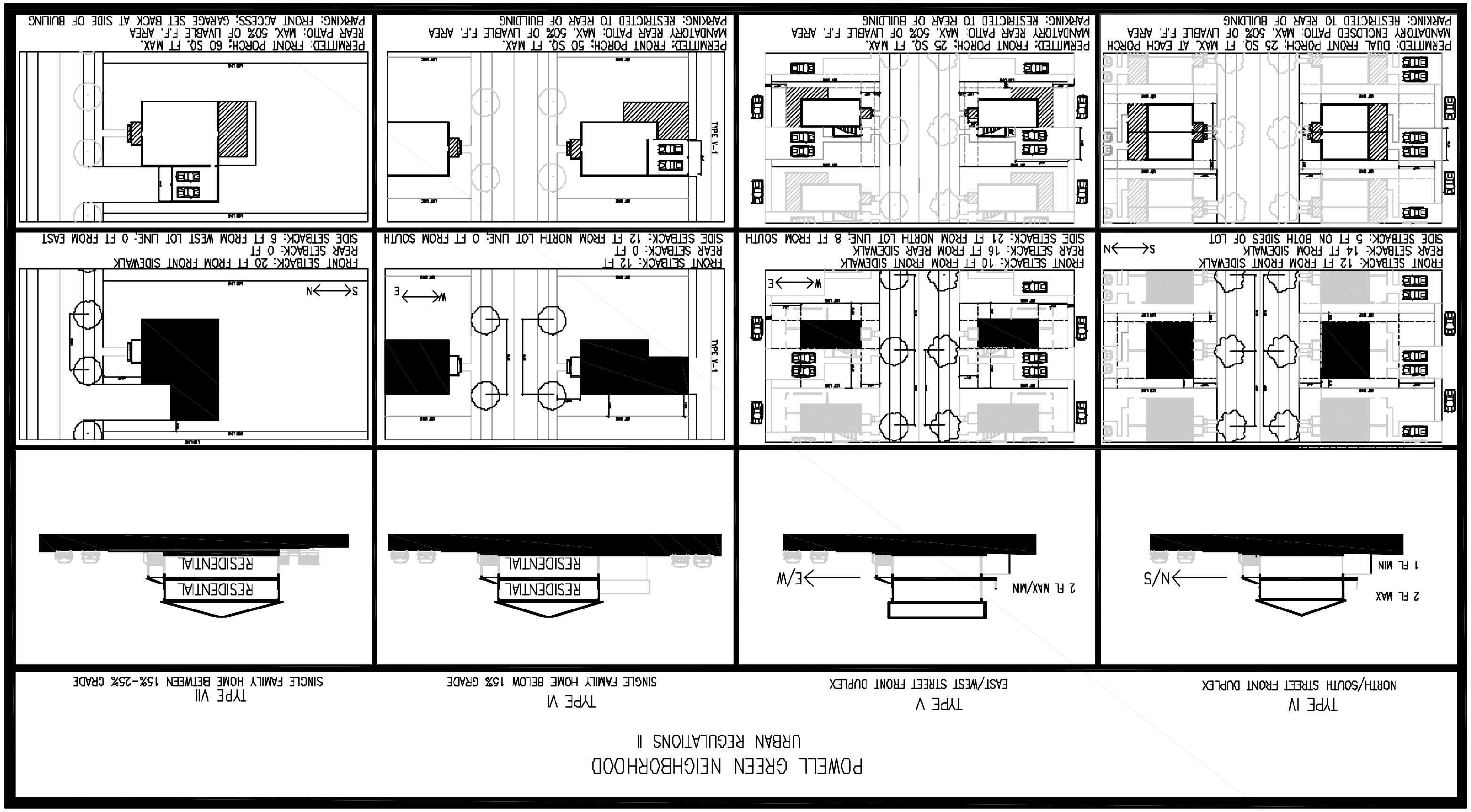

Figure 34: Powell Green Neighborhood Urban Regulations I
Urban Regulations I describes codes for higher density buildings found at the central core of the neighborhood. These regulations are adapted from contemporary neighborhood models with the inclusion of environmentally sensitive codes, such as tree type and placement, street type, and building envelope setbacks based on sun and shade patterns.

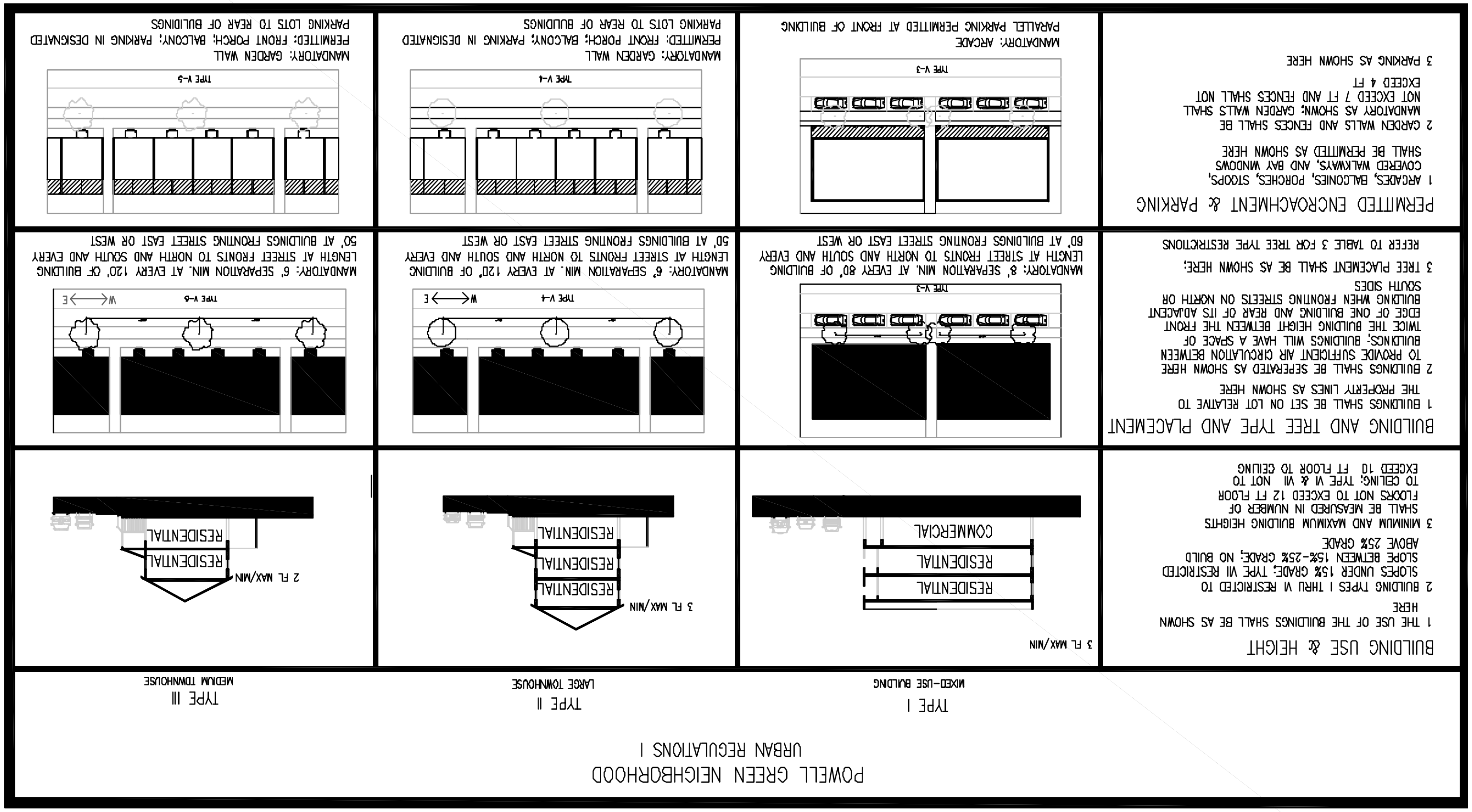

Figure 35: Powell Green Neighborhood Urban Regulations II
Urban Regulations II Represents medium and lower density housing found at the middle and perimeter of the Powell Neighborhood. These regulations have been adapted from contemporary neighborhood models with the inclusion of environmentally sensitive codes, such as tree type and placement, street type, and building envelope setbacks based on sun and shade patterns.

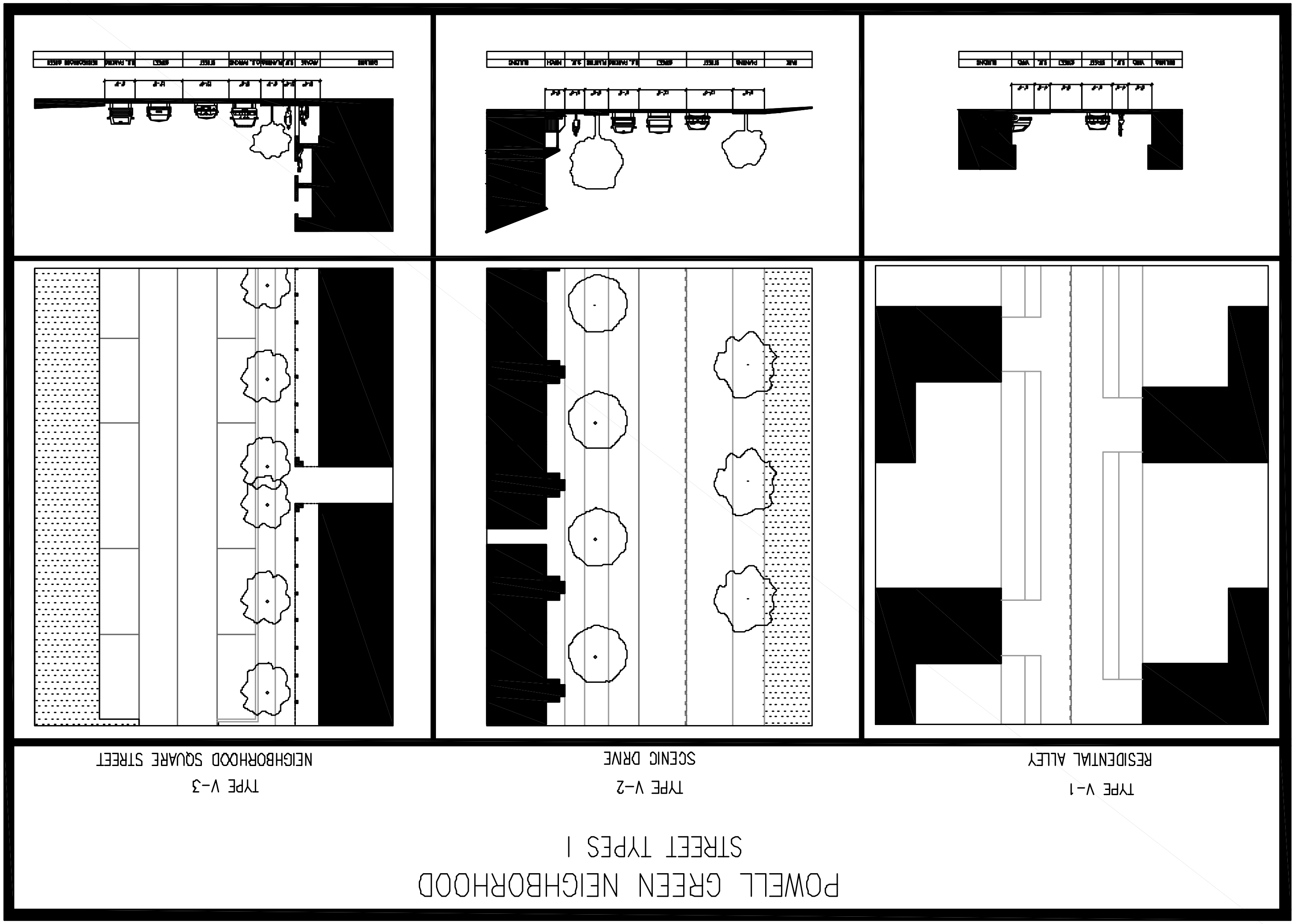

Figure 36: Powell Green Neighborhood Street Types I
Street Types I regulates street designs within the medium to high density residential and commercial zones and incorporates pedestrian friendly vehicular travel. All Powell Green Neighborhood street types have been adapted from contemporary neighborhood models with the inclusion of environmentally sensitive codes.

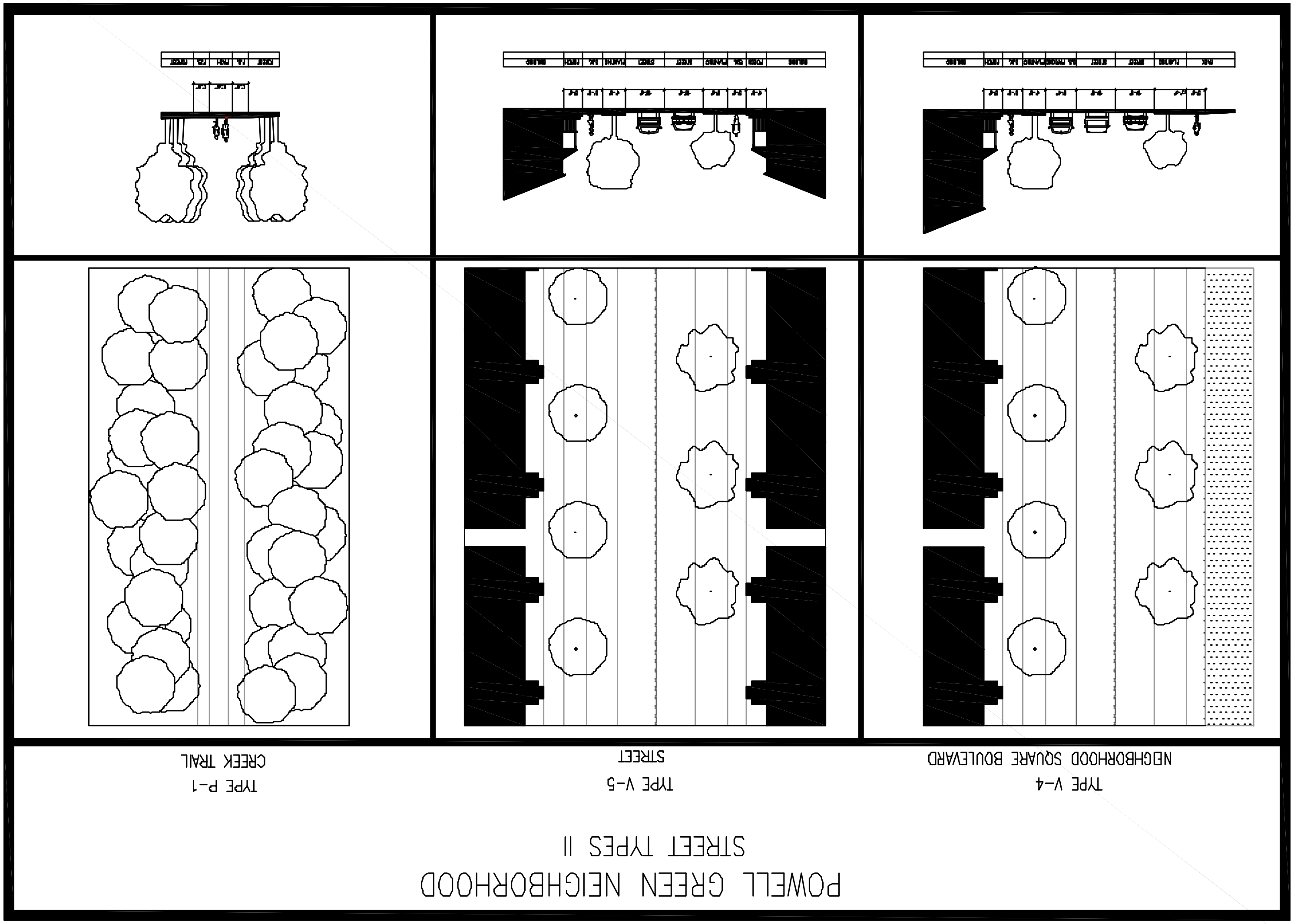

Figure 37: Powell Green Neighborhood Street Types II
Street Types II regulates street designs within the high density residential and greenway zones and incorporates pedestrian friendly vehicular travel as well as greenway pedestrian travel. All Powell Green Neighborhood street types have been adapted from contemporary neighborhood models with the inclusion of environmentally sensitive

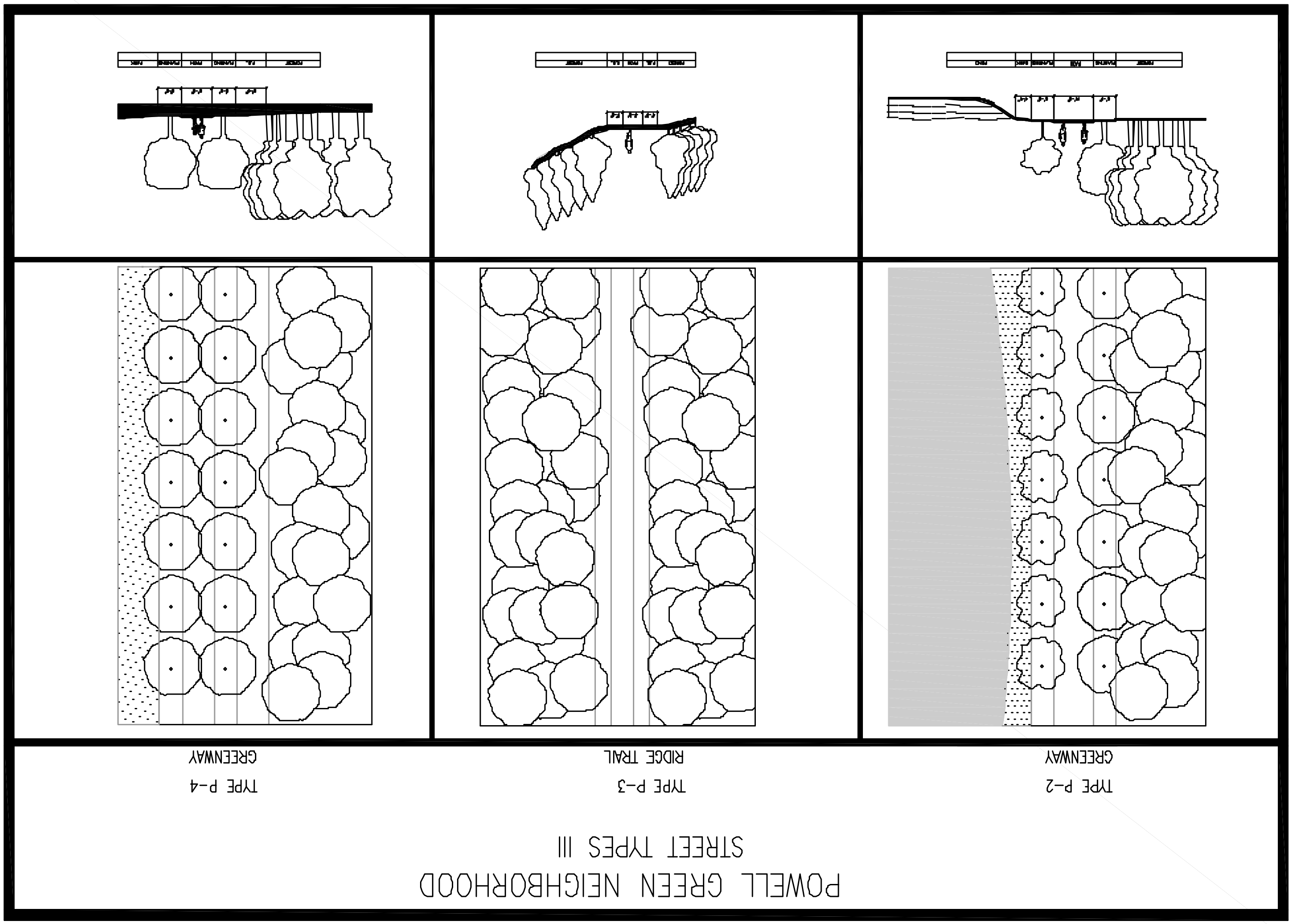

Figure 38: Powell Green Street Types III
Street Types III regulates street designs within greenway zones and incorporates greenway pedestrian travel. All Powell Green Neighborhood street types have been adapted from contemporary neighborhood models with the inclusion of environmentally sensitive codes.

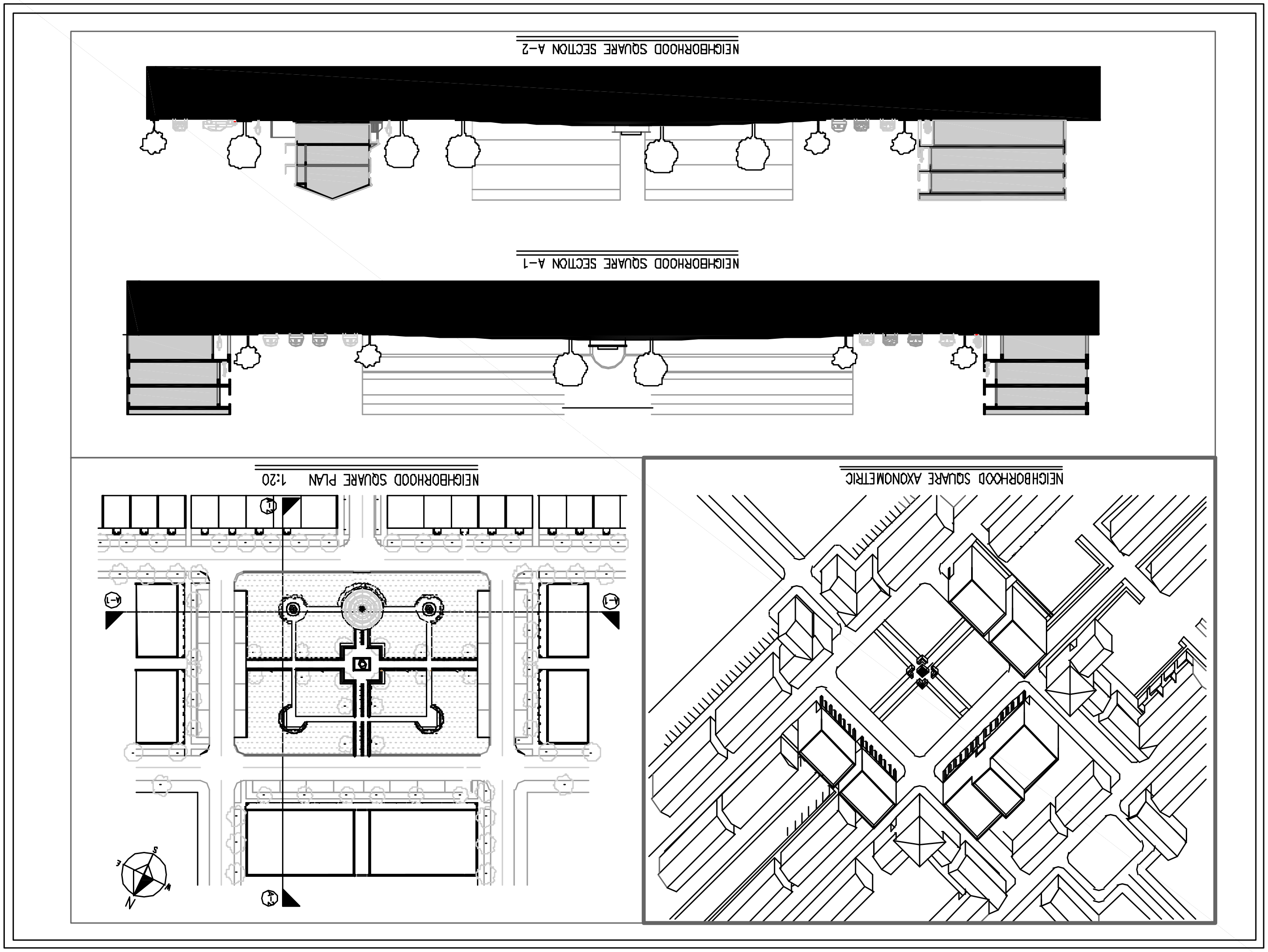

Figure 39: Powell Green Neighborhood Section I
Powell Green Neighborhood Section I has been cut through the neighborhood center. The green center acts as both a place of rest and an intersection to take people through the site. The green space is defined by mixed use buildings and apartments and includes pedestrian paths and a gazebo for social gathering. The section drawings represent the architectural form that has been developed using the ecological design patterns as integrated with contemporary urban codes and regulations.

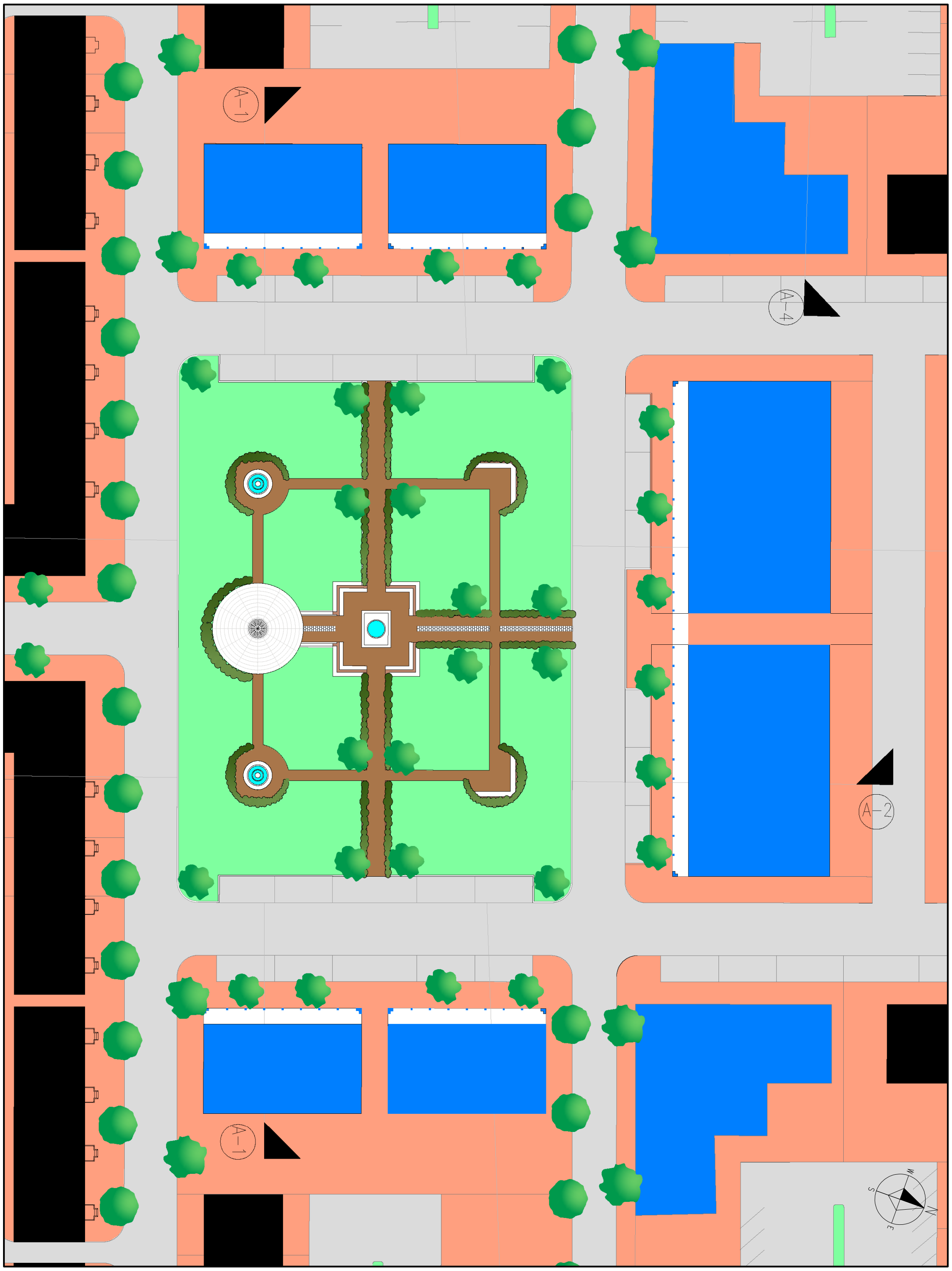

Figure 40: Powell Green Central Square This image shows the neighborhood green square in a color study. The neighborhood square features a series of ponds, outdoor seating, and a gazebo. These features have been designed to tie together the mixed-use and residential buildings using softscape. Water and vegetation offer an environmentally friendly atmosphere promoting social gathering at the center of the green neighborhood. The Gazebo and large open green space can be used to host social events, such as art shows, live music, and other community events.

Figure 41: Powell Green Central
The neighborhood center is defined by a green square at the core, surrounded by mixed-use buildings and apartments. Duplexes and single family housing outlines the neighborhood center perimeter. A street network has been designed to allow traffic to either avoid or weave through the neighborhood center. This is in an effort to control traffic flow in the neighborhood. Similarly, the street network works to connect the neighborhood green square with the neighborhood pond.

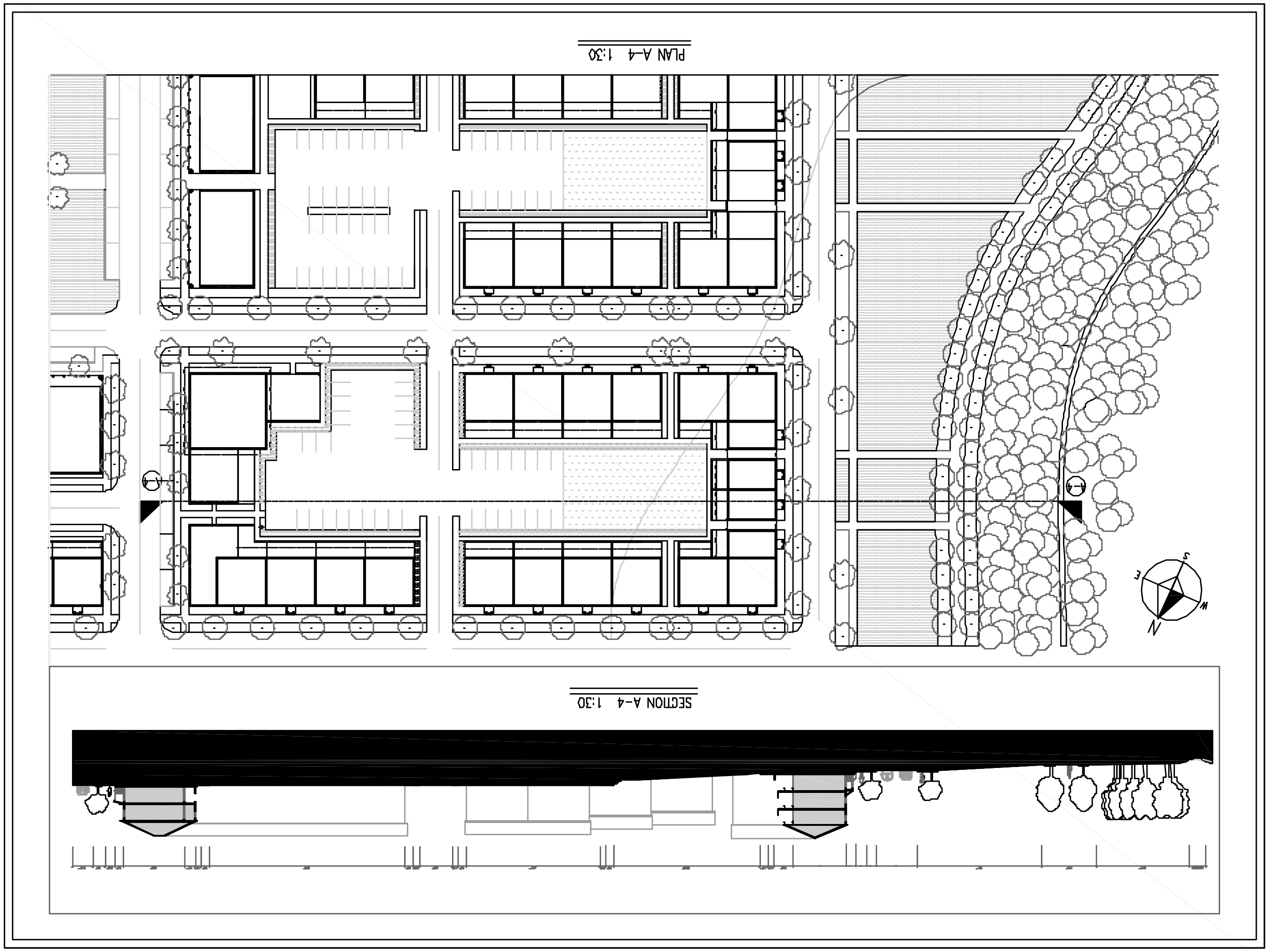

Figure 42: Powell Green Neighborhood Section II
Powell Green Neighborhood Section II has been cut along the west neighborhood center apartments, which overlook a portion of the greenway. The neighborhood center perimeter apartments have been designed with their own green spaces and parking and help to further define the neighborhood centers. The orientation, size, and spacing of the buildings was determined using solar and wind patterns as analyzed through this study. Similarly, the green spaces within the apartments have been designed and located using water flow patterns to more efficiently collect and return water to the Beaver Creek watershed. This drawing shows the architectural form that has been developed using the ecological design patterns as integrated with contemporary urban codes and regulations.

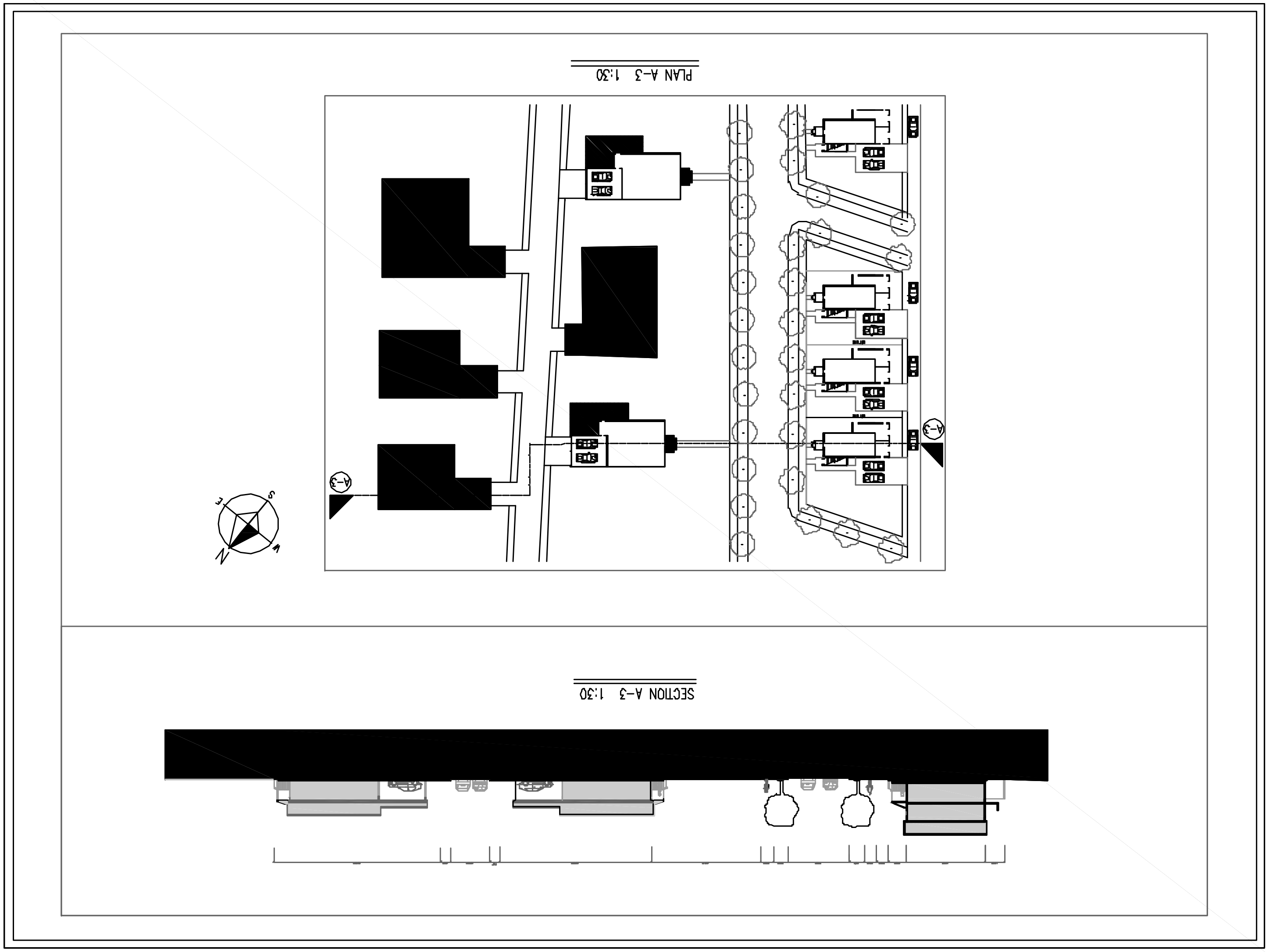

Figure 43: Powell Green Neighborhood Section III

Powell Green Neighborhood Section III has been cut through the medium to low density housing zones along the western perimeter of the site. The orientation, size, and spacing of the buildings was determined using solar and wind patterns as analyzed through this study. Streets and parking have been located to the rear of the buildings to promote pedestrian travel at the building fronts. This drawing represents the architectural form that has been developed using the ecological design patterns as integrated with contemporary urban codes and regulations.

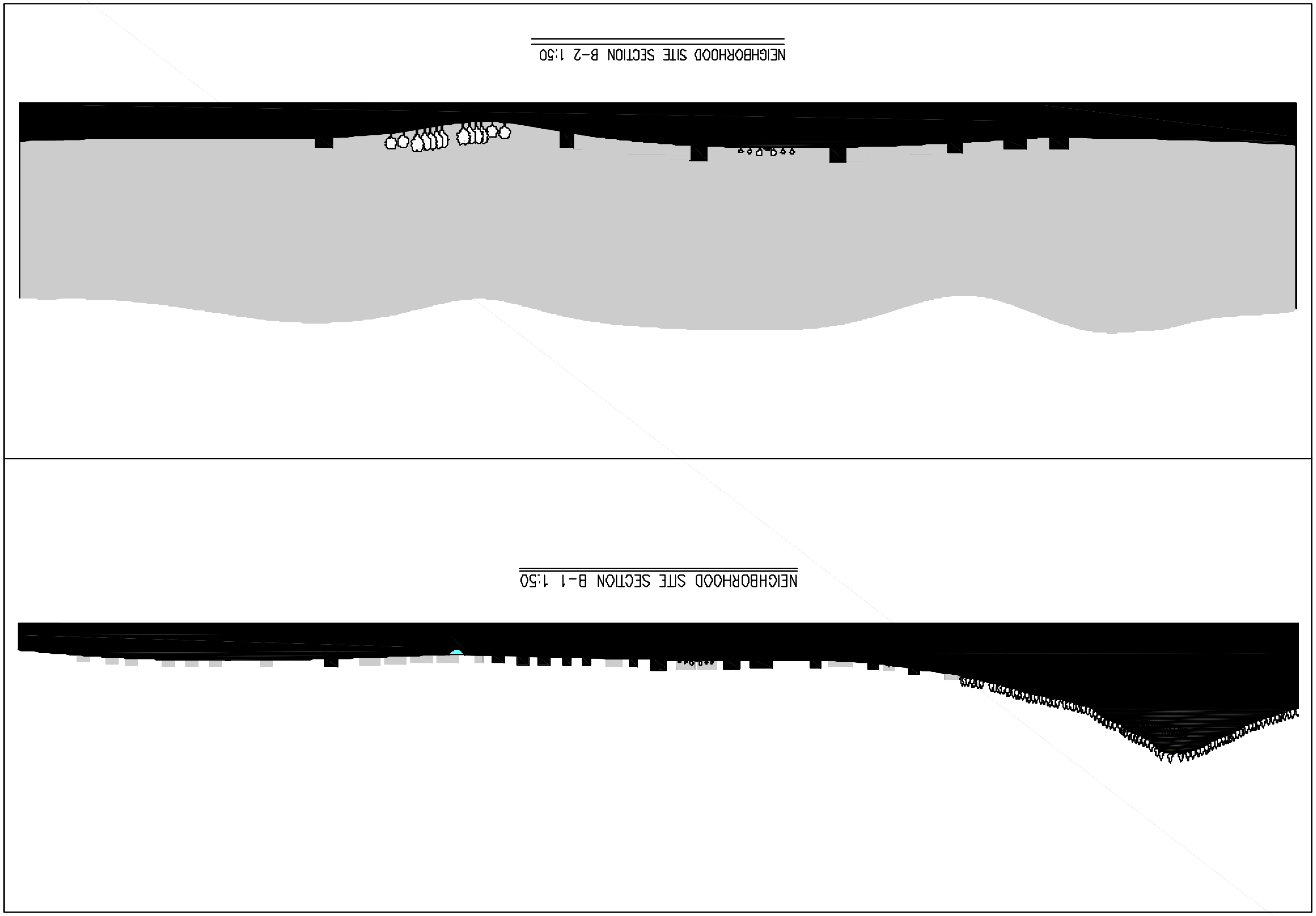

Figure 44: Powell Green Neighborhood Site Sections
Powell Green Neighborhood Site Sections has been cut North-South and East-West through the site. These sections show the distribution of buildings and green spaces throughout the site as designed using the slope pattern and revised urban codes and regulations. As seen in the sections, there is a higher density building density at the center of the neighborhood and a higher density green space along the perimeter of the site.

The goal of this thesis is to provide a process for rethinking urban design methodologies in an effort to promote the protection and regeneration of the natural environment. The integration of ecologically based design patterns into contemporary neighborhood best practices is the next step in urban development. The individual patterns and revised codes and regulations described throughout this study exemplify an approach to reaching this next step. The Powell Green Neighborhood created through this study reflects the physical articulation of the formulated ecological design strategies and solutions. These strategies were integrated into existing contemporary codes and regulations to demonstrate the means through which green neighborhoods can be created out of contemporary neighborhood models. It is neither impossible nor impractical to analyze ecological system patterns in order to formulate strategies to improve the impact of urban development on the natural environment. Through this study, improved social, economic, and environmental system design strategies were formulated to be used in the design of future green neighborhoods and ecologically sensitive urban developments.

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Appendices

Appendix 1: Case Studies/Precedents

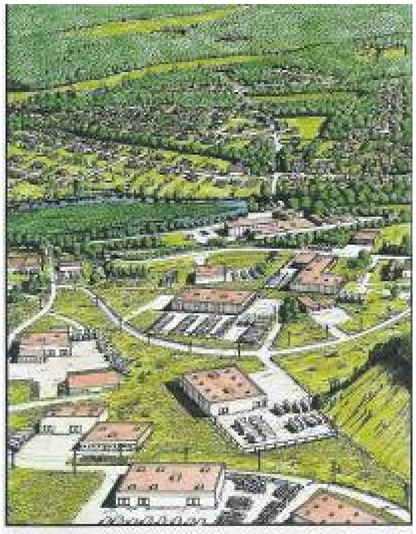


Figure 6-2. Aerial view after conventional development

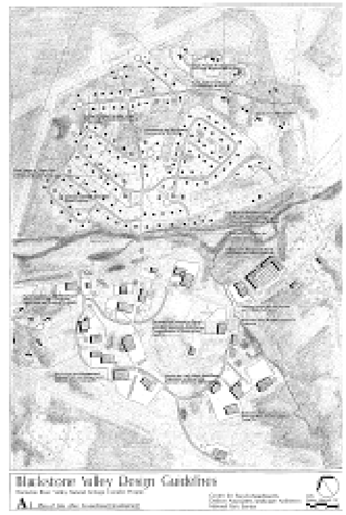


Figure 6-3. Site plan showing conventional development.

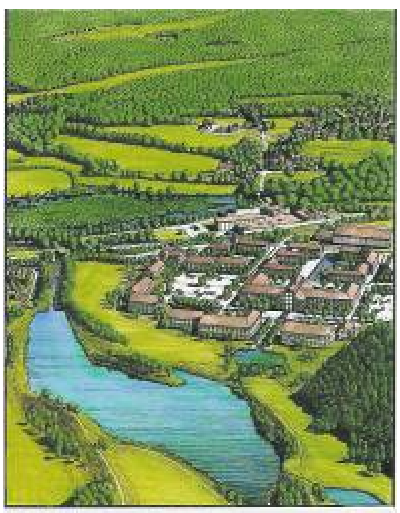
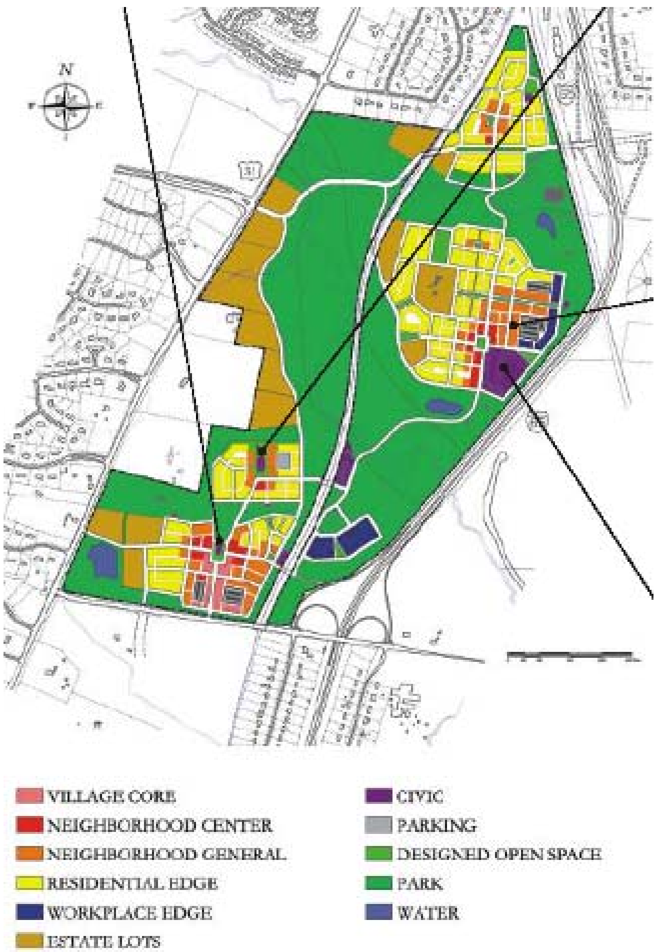


Figure 6-5. Aerial view after creative development.

Figure 6-6. Site plan showing creative development alternatives.

Land Conservation Studies

These are land conservation studies by Christien Reid (Arendt, 80, 84& 89-90). The top two images are of a conventional planning design. The bottom is a land conservation pattern developed neighborhood. These images are from Randall Arendts' book *Rural by Design.*



Town of Brentwood
These Images are of Brentwood, TN taken from the Dover, Kohl & Partners website: http://www.doverkohl.com/growing_new.html

The Brentwood area has a similar landscape and site context as the Powell site. It was designed using contemporary neighborhood planning methods similar to what will be used in this study.

Appendix 2: Codes and Regulations

Conventional Powell Zoning Codes

The Powell site is located in Knox County and has been zoned as a Town Center (TC) by the Metropolitan Planning Commission (MPC). The following information has been taken from the MPC zoning regulations for the Knox County area. The first table of regulations are for the mixed-use development sector and the second table of regulations are for the residential sector.

Town Center Mixed-Use Zoning for Knox County:

	Overview	**Sidewalk**	**Height/stories**
Core Area:	Pedestrian-oriented uses are required on the ground floor. Upper-story uses can include dwellings, offices, studios or other permitted. The minimum area shall be 2 acres. The core area should be created along a main street or public square.	10’ wide for 1-2 story with yard space 12’ for 2 story abutting sidewalk 14’ for higher than 2 stories	**Minimum:** Two stories **Maximum:** Determined by Planning Commission through approval
Peripheral Area:	This area can include a mix of uses on the various floors of buildings or a mix of single-purpose buildings, such as attached houses, apartments and office buildings. The maximum extension form the core area shall be 1,200 feet.	5’ wide with 7’ planting strip when 5’ yard space between building and sidewalk 12’ when building abutting sidewalk	**Minimum:** Two stories **Maximum:** 2-1/2 stories or 35 feet

* Metropolitan Planning Commission Zoning Ordinance for Knox County

Town Center Residential Zoning for Knox County:

Regulation	House
Minimum Lot Size	5,000 square ft. 5,500 square ft. on corner lot
Maximum Lot Size	None
Minimum Lot Width	40’, 45’ on corner lot, 50’ if a driveway is provided from the front of the property
Maximum Height	2-1/2 stories or 35’
Maximum Front Yard Setback	25’ to habitable portion of the house
Minimum Front Yard Setback	20’ to habitable portion of the house
Minimum Street Side Yard Setback	10’
Minimum Interior Side Yard Setback	5’
Minimum Rear Yard Setbacks; Main Building/ Accessory Buildings	25’/ 5’
Maximum Building Coverage	55%
Maximum Impervious Cover	65%

* Metropolitan Planning Commission Zoning Ordinance for Knox County

Contemporary Neighborhood *SmartCode* Summary

SMARTCODE TABLE 14 SMARTCODE SUMMARY

municipality

Note: All requirements in this Table are subject to calibration for local context.

R U R A L I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I U R B A N

	T1 NATURAL ZONE	T2 RURAL ZONE	T3 SUB-URBAN ZONE	T4 GENERAL URBAN ZONE	T5 URBAN CENTER ZONE	T6 URBAN CORE ZONE	SD SPECIAL DISTRICTS
A. ALLOCATION OF ZONES (see Section 3.1 and Table 2)							(see Table 15)
CLD	no minimum	50% MIN	10 - 30%	20 - 40%	prohibited		
TND	no minimum		10 - 30%	30 - 60 %	10 - 30%	prohibited	
RCD	no minimum		prohibited	10 - 30%	10 - 30%	40 - 80%	
TOD	no minimum		prohibited	0 - 30%	0 - 30%	40 - 100%	
B. BASE RESIDENTIAL DENSITY (see Section 3.4)							
By Right	1 unit / 100 ac. avg.	1 unit / 20 ac avg.	2 units / ac. gross	4 units / ac. gross	6 units / ac. gross	12 units / ac. gross	
By TDR	by Variance		6 units / ac. gross	12 units / ac. gross	24 units / ac. gross	96 units / ac. gross	
Other Functions	by Variance		10 - 20% min	20 - 30% min	30 - 50% min	50 - 70% min	
C. BLOCK SIZE							
Block Perimeter	no maximum		3000 ft. max	2400 ft. max	2000 ft. max	2000 ft. max *	
						* 3000 ft. max with parking structures	
D. PUBLIC FRONTAGES (see Tables 3 and 4)							
HW & RR	permitted			prohibited			
BV	prohibited		permitted				
SR	prohibited		permitted		prohibited		
RS	prohibited		permitted		prohibited		
SS & AV	prohibited				permitted		
CS & AV	prohibited				permitted		
Rear Lane	permitted				prohibited		
Rear Alley	prohibited		permitted	required			
Path	permitted				prohibited		
Passage	prohibited		permitted				
Bicycle Trail	permitted			prohibited *			
Bicycle Lane	permitted				prohibited		
Bicycle Route	permitted						
						* permitted within Open Spaces	
E. CIVIC SPACES (see Table 13)							
Park	permitted						
Green	prohibited		permitted			prohibited	
Square	prohibited			permitted			
Plaza	prohibited				permitted		
Playground	permitted						
F. LOT OCCUPATION							
Lot Width	by Variance	by Warrant	72 ft. min 120 ft. max	18 ft. min 96 ft. max	18 ft. min 180 ft. max	18 ft. min 700 ft. max	
Lot Coverage	by Variance	by Warrant	60% max	70% max	80% max	90% max	
G. BUILDING DISPOSITION							
Front Setback	by Variance	48 ft. min	24 ft. min	6 ft. min 18 ft. max	0 ft. min 12 ft. max	0 ft. min 12 ft. max	
Side Setback	by Variance	96 ft. min	12 ft. min	0 ft. total min	0 ft. min 24 ft. max	0 ft. min 24 ft. max	
Rear Setback	by Variance	96 ft. min	12 ft. min	3 ft. min *	3 ft. min *	0 ft. min	
						* or 15 ft. from center line of alley	
H. BUILDING TYPE (see Table 9)							
Edgeyard	permitted				prohibited		
Sideyard	prohibited			permitted		prohibited	
Rearyard	prohibited			permitted	permitted		
I. PRIVATE FRONTAGES (see Table 7)							
Common Yard	not applicable	permitted		prohibited			
Porch & Fence	not applicable	prohibited	permitted		prohibited		
Terrance or L.C.	not applicable	prohibited		permitted		prohibited	
Forecourt	not applicable	prohibited		permitted			
Stoop	not applicable	prohibited		permitted			
Shopfront & Awning	not applicable	prohibited		permitted			
Gallery	not applicable	prohibited		permitted			
Arcade	not applicable	prohibited			permitted		
J. BUILDING HEIGHT (see Table 8)							
Principal Building	not applicable	3 stories max		4 stories max, 2 min	6 stories max, 2 min	12 stories max, 2 min	
Outbuilding	not applicable	2 stories max		2 stories max	2 stories max	not applicable	
K. BUILDING FUNCTION (see Table 10 &11)							
Residential	prohibited	restricted use		limited use	open use		
Lodging	prohibited	restricted use		limited use	open use		
Office	prohibited		restricted use	limited use	open use		
Retail	prohibited		restricted use	limited use	open use		

DISPOSITION

CONFIGURATION

FUNCTION

ARTICLE 5

ARTICLE 2, 3, 4

SC129

SmartCode Version 8.0

SmartCode Summary:

This image is from the Urban Transect zoning model. It is a geographical cross section that "extends the natural environments to the human habitat by increasing density and immersive urban character" (Duany, 2).

Contemporary Neighborhood Principles

Neighborhoods, as defined by Andres Duany and Elizabeth Plater-Zyberk, are "Urbanized areas with a balanced mix of human activity" (Katz, xvii). In terms of the ideal neighborhood, five principles have been established from New Urbanism:

Principle for the Neighborhood:
1) The neighborhood has a center and an edge
2) The optimal size of a neighborhood is a quarter mile from the center to edge
3) The neighborhood has a balanced mix of activities-dwelling, shopping, working, schooling, worshipping and recreating;
4) The neighborhood structures building sites and traffic on a fine network of interconnecting streets
5) The neighborhood gives priority to public spaces to the appropriate location of civic buildings.
(The New Urbanism, xvii)

These principles have been created as contemporary neighborhood best practice in an effort to regenerate social and economic events and processes within the urban environment. Although these principles encourage land conservation and the reduction of vehicular dependency, the benefits are minimal in the effort to create a sustainable neighborhood. If sustainable development must address social, economic, and ecological systems, then it is necessary to integrate ecological design patterns with contemporary neighborhood principles.

Vita

Joseph Paul Goldman was born in Miami, Florida on December 22, 1982. In 2001, he graduated high school from University School of Nova Southeastern University in Davie, Florida. He received a B.A. in architecture from Lehigh University in Bethlehem, Pennsylvania and a M.A. in architecture from the University of Tennessee, 2005 and 2008 respectively. In 2007, Joseph began working with Acanthus Architecture in Winston-Salem, North Carolina, where he currently resides.